Pelagic Fish Surveys of 20 Lakes in Northern British Columbia From: 2006 to 2009

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ABSTRACT

MacLellan, S.G. and Hume, J.M.B. 2011. Pelagic fish surveys of 20 lakes in Northern British Columbia from: 2006 to 2009. Can. Tech. Rep. Fish. Aquat. Sci. 2950: viii + 139 p.

We conducted pelagic fish surveys using hydroacoustics, midwater trawls and small mesh gillnets in 20 sockeye (*Oncorhynchus nerka*) rearing lakes in the Nass and Skeena river systems and in the north and central coast regions of British Columbia. We present the results in relation to lake water type and provide detailed results for each lake. We detected differences in vertical distribution, species composition and diet between clear, stained and glacially turbid lakes. Clear lakes had the most diverse pelagic fish community but age-0 *O. nerka* (mostly sockeye) were the most common species found. Glacially turbid lakes had far fewer species and age-0 *O. nerka* were the most common. Threespine stickleback (*Gasterosteus aculeatus*) and age-0 *O. nerka* were the dominant species in the stained lakes. *Daphnia* were the dominant prey item of age-0 *O. nerka* in clear lakes while *Bosmina* dominated in the diets in stained lakes. Copepods and terrestrial insects were the most common prey items in glacially turbid lakes.

RÉSUMÉ

MacLellan, S.G. and Hume, J.M.B. 2011. Pelagic fish surveys of 20 lakes in Northern British Columbia from : 2006 to 2009. Can. Tech. Rep. Fish. Aquat. Sci. 2950: viii + 139 p.

En nous servant de la détection hydroacoustique, de chaluts méso-pélagiques et de filets maillants à petit maillage, nous avons effectué des relevés sur les poissons pélagiques dans 20 lacs d'alevinage du saumon rouge (*Oncorhynchus nerka*) dans les réseaux de la Nass et de la Skeena et sur les côtes centrale et nord de la Colombie-Britannique. Nous présentons les résultats selon le type d'eau de ces lacs. Nous avons relevé des différences dans la distribution verticale, la composition spécifique et l'alimentation entre les lacs aux eaux claires, les lacs aux eaux sombres et les lacs glaciaires aux eaux turbides. Les lacs aux eaux claires renfermaient la communauté de poissons pélagiques la plus diversifiée, bien que *O. nerka*, sous la forme d'individus d'âge 0, était l'espèce la plus commune qui s'y trouvait. Les lacs glaciaires aux eaux turbides renfermaient beaucoup moins d'espèces, mais *O. nerka*, sous la forme d'individus d'âge 0, y était aussi l'espèce la plus commune. L'épinoche à trois épines (*Gasterosteus aculeatus*) et *O. nerka*, sous la forme d'individus d'âge 0, étaient les espèces dominantes dans les lacs aux eaux sombres. *Daphnia* constituait la proie dominante des saumons rouges d'âge 0 dans les lacs aux eaux claires. *Bosmina* constituait l'élément dominant des régimes alimentaires des poissons dans les lacs aux eaux sombres, alors que les copépodes et les insectes terrestres étaient les proies les plus communes dans les lacs glaciaires aux eaux turbides.

INTRODUCTION

The effective management of sockeye salmon (*Oncorhynchus nerka*) stocks requires reliable estimates of abundance, but sockeye salmon stocks along the central and north coast of British Columbia and in the Skeena and Nass watersheds are many, tend to be small, widely dispersed, and are often remote with difficult access. This combination of factors makes traditional adult enumeration of spawning populations both expensive and difficult to conduct from year to year. Pelagic surveys of juvenile sockeye salmon using hydroacoustics and trawl nets offer an easier and cost effective alternative assessment method (MacLellan and Hume 2010).

The results of pelagic fish surveys of 23 sockeye salmon rearing lakes, surveyed from 1997 to 2005, in the Skeena River watershed and on the north coast of British Columbia were reported in Hume and MacLellan (2008). In this paper we report on an additional 20 lakes surveyed from 2006 to 2009. These lakes were located in the Skeena and Nass river watersheds and on the north and central coast of British Columbia.

The primary objective of most of these surveys was to assess the stock status of the sockeye populations and their competitors in the study lakes. We did this by estimating pelagic fish abundance using mobile hydroacoustic surveys accompanied by midwater trawling and gillnetting. However, three lakes, (Batchellor, Red Bluff and Whalen lakes), known as hanging lakes, have waterfalls on their outflow creeks, which are barriers to anadromous fish passage, and therefore had no existing sockeye populations utilizing the lake. The Gitga'at First Nation, based at Hartley Bay, initiated a project to investigate the feasibility of using these hanging lakes to rear sockeye fry in support of a terminal fishery on the returning adults at the mouth of the outlet creek. Thus, our objective on these three lakes was to support the Gitga'at hanging lakes study by collecting information on the existing pelagic and littoral fish populations of these lakes, for the purpose of evaluating each lake for its suitability to rear out-plants of juvenile sockeye.

While some lakes in this report and in Hume and MacLellan (2008) have been surveyed previously, these are the first pelagic (acoustic and trawl) fish surveys of many of the lakes (28 of 42). In Hume and MacLellan (2008), the study lakes were divided into three different water types; clear, dystrophic (stained) and glacial, where glacial was defined as a lake with any direct influence by glacial melt waters. In this paper, we present the results in relationship to these water types, but have modified the definition of glacial lakes to only include glacially turbid lakes that have significantly decreased light transmission rates (Lloyd et al. 1987, see methods). A number of lakes that were previously classified as glacial would now be classified as clear using the new criteria.

THE STUDY LAKES

The 20 study lakes are located in five regions of British Columbia (Fig. 1, Table 1). Four of the lakes are within the Nass River watershed and include Meziadin, Bowser, Fred Wright, and Kwinageese lakes. All are located inland and sockeye migrations to and from the ocean range from about 170 km to 250 km. Alastair and Morice lakes are both in the Skeena watershed but differ greatly in climate and circumstance. Alastair is near coastal in nature, being only 45 m above sea level, and a relatively short migration distance (70 km) from the ocean and is frequented by harbour seals (*Phoca vitulina*). Morice on the other hand is well inland, at an elevation of 763 m, and migrating salmon travel 425 km to get to this lake. Lonesome and Elbow lakes are located in the Atnarko Valley in the interior Bella Coola region and are part of Tweedsmuir Provincial Park. These lakes are approximately 100 km upstream of the ocean and elevations are 485 m and 590 m respectively. Lastly, lakes in the north and central coast regions of British Columbia are on the islands and peninsulas of the British Columbia coast. Typically their outlets flow only a short distance to the ocean, often only a kilometer or two, and they are subject to a maritime climate. On the north coast we surveyed Batchellor, Red Bluff and Whalen lakes for the hanging lakes study, and Keecha, Kooryet, Moore, Kitlope and Kimsquit lakes to assess sockeye stock status. On the central coast we surveyed Koeye, Namu, and the Tankeeah lakes (upper and lower) to assess sockeye stock status.

Most of the coastal lakes were of the stained water type, with only Kitlope and Kimsquit lakes being categorized as clear. All interior lakes were either clear or glacially turbid. Lake size varied greatly, from Tankeeah Upper Lake at 129 ha to Morice Lake covering 9 738 ha. The shallowest lakes were the two Tankeeah lakes with average depths of 8 and 10 m, while Whalen and Morice lakes had average depths around 100 m. Moore Lake is at the lowest elevation of all our study lakes at only 5 m above sea level, and has a saline layer in its lower basin starting at about 20 m depth, suggesting possible periodic incursions of salt water from the ocean. The highest study lake is Morice at 763 m above sea level. Pelagic fish densities range from a high of 6 472 fish/ha in clear Alastair Lake to 39 fish/ha in glacially turbid Bowser Lake.

METHODS

FIELD DATA COLLECTION

We surveyed populations of pelagic fish using hydroacoustic and midwater trawling techniques developed for juvenile sockeye salmon (Burczynski and Johnson 1986, Hume et al. 1996, Hyatt et al. 1984, Hume and MacLellan 2008, MacLellan and Hume 2010). In preparation for each lake survey, we developed a survey design as in Hume and MacLellan (2008), but increased the minimum number of transects per lake to seven, in order to reduce the variance in the abundance and density estimates (Figs. 2a to 2t). Data and sample collection in the field was done the same as in Hume and MacLellan (2008). Surveys were conducted in late summer and early fall from September 1 to September 22, except for hanging lake surveys which were done between July 21 to 26 in 2006 (Table 1). Each lake was surveyed only once.

Fish Sampling

We used a 4.3 m inflatable boat (the Little Echo) with a 2x2 m mid-water trawl for lakes that could only be accessed by plane. Meziadin and Morice lakes had road access and were surveyed with a 7.3 m aluminum power boat (the Night Echo) with a 3x7 m closing trawl (Hume and MacLellan 2008, MacLellan and Hume 2010). Trawling was our primary method of sampling the pelagic fish populations, but we collected additional fish samples with Swedish style gill nets, which were 1.5 m deep and consisted of four, 4 m long panels, with stretched mesh sizes of 12.5, 16, 20, and 25 mm (Appleberg 2000, MacLellan and Hume 2010). On a couple of surveys we tried using regular small mesh gill nets as well (19 and 25 mm stretch mesh, 7.5 x 2.0 m panels), but discontinued their use as they were ineffective. On the hanging lake surveys we used additional gears including RIC gill nets (seven, 7.5 x 2.0 m panels, consisting of 19, 64, 38, 89, 51, 76 and 25 mm stretch mesh), minnow traps, beach seines and dip nets to evaluate fish populations in the littoral zone of the lake. Small fish were preserved in 1 liter plastic sample bottles using 10% formalin or 85% ethanol and processed later at Cultus Lake Laboratory. Fish too large for our sample bottles were measured for fork length and released.

Hydroacoustic Sampling

Hydroacoustic sampling was done similarly to Hume and MacLellan (2008). We used a Biosonics (www.biosonicsinc.com) DTX split beam sounder, transmitting at 208 kHz with a 6.6 degree circular beam. As in our earlier surveys we used a 0.4 ms pulse width, but our collection threshold decreased over the 4 years covered by this paper. In 2006, we collected at -70 dB; in 2007 we decreased this to -75 dB to aid in detecting smaller organisms such as *Chaoborus* larva, and in 2008 we began collecting at -100 dB when improvements to our collection software allowed us to collect data at a lower threshold (-100 dB) but view it at a higher threshold (-75 dB).

Bathymetric charts are required for several aspects of a hydroacoustic assessment and we obtained existing charts for eight of our study lakes from the British Columbia Ministry of Environment, Fisheries Data Warehouse (http://a100.gov.bc.ca/pub/fidq/main.do). However, two of these charts (Figs. 3a and 3c), Alastair and Bowser Lakes, did not agree well with the survey soundings, so we created new charts for these lakes based on the transect and other soundings we took during the survey. Coverage for these two charts were not as complete as normally obtained, but represented the observed bathymetry of these lakes better than the existing charts. No existing charts were available for the 12 remaining study lakes, and we compiled new charts using the same techniques and software described in MacLellan and Hume (2010). Besides depth data from the survey transects, we used data from transects between survey transects as well as additional sounding in shoal areas and from transects running the long axis of the lake (when time permitted), to construct these charts (Figs. 3b, 3d to 3n).

Zooplankton Sampling

We used replicated vertical Wisconsin hauls to sample the zooplankton in the pelagic zone of our study lakes as described in Shortreed et al. 2007). The Wisconsin net had a mouth opening of 0.05 m^2, a mesh size of 160 μm, used a flow meter mounted on the second ring to measure net efficiency, and was hauled from a depth of 30 m where lake depth permitted. Samples were preserved in 125 ml plastic bottles using a sucrose buffered 4% formalin solution. These samples were collected one of two ways, either by our hydroacoustic crew at the time of our survey, or by our limnology crew as part of a more extensive limnology survey of the lake. In the latter case, zooplankton sample dates do not correspond exactly with our hydroacoustic surveys but are usually within a month of one another, except for Keecha, Kooryet, and Moore Lakes, where the limnology and hydroacoustic surveys were 4 years apart.

Some of the study lakes have *Chaoborus* populations inhabiting the pelagic zone and the Wisconsin net does not adequately sample these populations for various reasons (Shortreed et al. 2007). To sample *Chaoborus* and other macro-invertebrates we used a 350 μm mesh SCOR-type net. This net had a 0.25 m^2 opening and typically was fished in the same manner as the Wisconsin net, except sampling was done at night. Samples were preserved in the same manner as zooplankton.

SAMPLE AND DATA PROCESSING

Hydroacoustic Methods

In this study, we used Myriax's Echoview software (www.echoview.com) to process hydroacoustic data. We used four techniques in analyzing the data, echo integration (NTG), single target analysis (ST), track target analysis (TT) and a variation on tracked target analysis we call *Chaoborus* tracked target analysis (Cha-TT) (MacLellan and Hume 2010). A modified tracked target analysis (Cha-TT) is needed when *Chaoborus* larva are present in the water column in significant numbers, as they reflect sound energy similarly to juvenile sockeye and will inflate the sockeye estimate unless removed from the acoustic data. Each of these methods is described in Hume and MacLellan (2008) and MacLellan and Hume (2010), and were used to process the data collected from the study lakes. As in MacLellan and Hume (2010) we usually report integration results for fish densities >500/ha, TT results where survey densities are <500/ha and Cha-TT results when *Chaoborus* is present in significant numbers.

Fish and Diet Samples

Fish and diet samples were processed as described in Hume and MacLellan (2008) and MacLellan and Hume (2010). Large fish were measured for fork length in the field and released. Smaller fish were preserved in 10% formalin or 85% ethanol and transported back to the lab for processing. After at least 30 days of preservation, fish were measured for fork length (mm), weighed (g), and where possible, scales were taken from *O. nerka* for age determination.

Stomach samples were taken from selected groups (species, size classes, location in lake) of fish, usually from trawl captured fish that were caught within 3-4 hrs after dusk (normal *O. nerka* feeding time). Up to ten fish stomachs were combined in a sample vial, containing a solution of 10% formalin, for diet analysis. Where possible a replicate sample of up to ten fish was taken for each group. During analysis, each individual stomach was assessed for fullness and its contents combined with that of the other stomachs from the vial. These stomach contents were then sub-sampled as necessary, identified, counted, and where possible, measured, using a computerized video measuring system as described in MacLellan et al. (1993). With these data, mean numbers of food items per stomach were calculated and biomass was estimated using length-weight regressions. See MacLellan and Hume (2010) for details.

Insects comprised a portion of the diet in a number of lakes in this report, but due to their state of digestion, assessing abundance and biomass of terrestrial insects in the diet was difficult, resulting in imprecise estimates (MacLellan and Hume 2010). Nevertheless, these numbers do indicate the presence or absence of insects, and given their individual size relative to most freshwater zooplankton, it takes few insects to make a significant contribution to the biomass of a juvenile sockeye's diet.

Zooplankton Samples

Zooplankton and macro-invertebrate samples were processed using a computerized video measuring system (Shortreed et al. 2007, MacLellan et al. 1993). Samples were sub-sampled as necessary and individual zooplankton were identified, counted and measured. Biomass was estimated using taxa-specific length-weight regressions (MacLellan and Hume 2010).

RESULTS AND DISCUSSION

In this section we discuss the limitations and biases of the sampling gear, and provide an overall analysis of the catch in relationship to water clarity. Specific results of the survey of each study lake including methodology, difficulties encountered, and a description of the pelagic fish communities are presented in Appendix 1. We also evaluate each lake's suitability for hydroacoustic assessment and recommend strategies for any future surveys on these lakes. We also present details of the sampling performed (tow log, Appendix 2), population estimates using the four different analytical techniques (Appendix 3), catch and size data for each gear type (Appendix 4), and detailed results of the diet analysis (Appendix 5).

LAKE CLASSIFICATION

Hume and MacLellan (2008) classified lakes into three categories (clear, stained and glacial), and reported results with respect to these groups. The glacial group included any lake that was subject to glacial melt waters and displayed the typical coloration caused by fine suspended glacial sediment. For this paper, we revised the approach to glacial lakes. We observed that many glacial influenced lakes had relatively deep euphotic zones and juvenile sockeye behavior (diel vertical distribution and diet) was similar to that found in clear lakes. It seemed reasonable that the degree to which these lakes were affected by glacial melt waters was important in determining the extent of the effect on lake productivity and sockeye behaviour. Lloyd et al. (1987) found that compensation depth (depth to which 1% of ambient surface light penetrates) decreased rapidly above turbidities of 5 NTUs. They also found that reduced light penetration in the water column led to reduced zooplankton density and that glacial turbid lakes in Alaska, lacked Cladocera, in particular *Daphnia*, a favoured food of juvenile sockeye (Lloyd et al. 1987). We therefore restricted the glacial lakes category to those lakes with turbidity readings >5 NTUs, and re-labeled it as "glacially turbid" (Table 1). Less glacially influenced lakes became part of the "clear" lakes group. We did not have turbidity readings for a few study lakes but did know the compensation depth. We estimated turbidity for these lakes using a linear regression developed from the other lakes that had both turbidity and light compensation depth data. Stained lakes were visually classified by field crews observing water colour at the time of sampling. More quantitative methods for measuring the degree of staining would provide a more robust categorization. Using the revised classification scheme, only Bowser Lake was classified as glacially turbid, 9 lakes were classified as clear (6 had some glacial influence) and 10 lakes were classified as stained (Table 1).

BIASES IN SAMPLING EQUIPMENT

The selectivity of the trawls and gillnets used in these surveys is discussed in MacLellan and Hume (2010), and as is the case for all sampling equipment, the sampling gear is size selective (Simmonds et al. 1992). MacLellan and Hume (2010) conclude from a review of the literature and their own studies that there is little difference in trawl efficiency (catch /m^3) or size bias between the two trawls sizes used (2x2 m and 3x7 m) when sampling age-1 and smaller sized fish, but that both provide size estimates that are smaller than that of the true population. The amount of the bias was quite variable amongst the reported studies.

The small mesh gillnets were selected to specifically sample smaller fish (age-0 and -1 *O. nerka* and other similar sized fish) and were utilized to supplement and to expose any bias in the small trawl catch. While the size range of *O. nerka* caught by gill nets tends to overlap with that of the 2x2 m trawl, the gill nets will catch fish considerably larger than the 2x2 m trawl and were useful in determining the presence of older age classes of *O. nerka* and of larger competitors and predators (Fig. 4a).

For the lake surveys covered by this report, a comparison of September caught *O. nerka* by the two trawls indicates that both gears performed equally well for fish up to 75 mm in length. The large trawl, however was more successful capturing larger *O. nerka*, in the 75-110 mm range, than was the small trawl (Fig. 4b). Although most of the large trawl catch (99%) comes from the Meziadin Lake survey and no gill nets were used on Meziadin, it does demonstrate the large trawl's ability to catch this larger size class when they are present in the pelagic fish population. The small trawl on the other hand, appears to steadily decline in its ability to catch fish larger than 75mm in length, despite indications from the gill net catch that *O. nerka* in this larger size class were encountered (Fig. 4a). Results from this and previous studies suggest that there is size bias in the trawl data, but it is variable. (MacLellan and Hume 2010, Hyatt et al. (2004) and McQueen et al. (2007). This is likely because more factors affect trawl net efficiency than just fish size, such as trawl depth, water clarity, and light conditions.

FISH SPECIES COMPOSITION AND SIZE

Pelagic Fish Composition - Trawl and Gill Net Samples

Trawling was the most effective fish sampling technique. A total of 2 182 minutes of trawling in 109 trawls with the 2x2 m net caught 2 266 fish for a catch rate of 62 fish/hr, while 155 minutes of trawling in nine trawls with the larger 3x7 m trawl caught 1 065 fish, for a catch rate of 412 fish/hr (Table 2). Most trawls targeted depths where fish were seen on the echo sounder, while a few targeted the surface layers, an area of the lake not sampled by the echo sounder, to check for surface oriented fish populations. Trawls caught mainly *O. nerka* and stickleback in clear and stained lakes, while only *O. nerka* were caught in glacially turbid Bowser Lake (Table 3, 4). Other trawl caught species included sculpin (*Cottus* sp), coho salmon (*O. kisutch*) and Dolly Varden (*Salvelinus malma*) (Table 4). Clear and stained lakes produced age-0 *O. nerka* of similar size (57-58 mm), while clear lakes produced larger age-1 *O. nerka* than those in stained lakes. The glacially turbid lake had the smallest age-0 and age-1 *O. nerka* at 52mm and 70mm. Stained lakes produced larger stickleback and sculpin than did clear lakes. (Table 5)

From 2006 to 2009 we set small mesh Swedish gill nets overnight on 94 occasions for a total of 1 813 hours of fishing time, catching 305 fish. This is an over all catch rate of 3.2 fish/set or an average of 16.9 fish/survey (Table 2). While the general catch of the Swedish gill nets was lower than the trawls, it's clear from CPUE data that they performed poorest in stained lakes, with a CPUE rating an order of magnitude lower than that experienced in either clear or glacially turbid lakes (Table 2). This, despite the fact that the 2x2 m trawl had the highest CPUE in stained lakes than in either of the other water types (Table 2). These gill nets were only 1.5 m deep and for the most part we set them over as deep water as practical to sample the pelagic region of the lake and submerged them to a depth near the thermocline. The Swedish gill nets caught fewer fish than did the trawls but caught a wider variety of species (Table 2). In all lake types, the Swedish gill nets caught *O. nerka* and stickleback that were larger than those captured with the trawl (Table 5). Again, clear and stained lakes produced similar sized age-0 *O. nerka*, with the glacially turbid lake producing smaller age-0 *O. nerka* and stained lakes had larger stickleback than did clear lakes (Table 5). Gill nets were not used for the Meziadin or Morice Lake surveys where the large 3x7 m trawl was employed.

In summary, trawl and Swedish gill net data indicated that clear and stained lakes produced similar sized *O. nerka*, while glacially turbid lakes produced somewhat smaller fish. It also showed that stickleback tended to be larger in stained lakes than in clear lakes and they appeared to be absent from the glacially turbid lakes in our study.

Hanging Lakes – Fish Composition

On Batchellor, Red Bluff, and Whalen lakes regular (RIC) gill nets, minnow traps, dip nets and beach scenes were employed close to shore in the littoral zone to sample the near shore fish community. The 2x2 m trawl and Swedish gill nets were mainly used to assess the pelagic zone. All three of these lakes were stained and had outlet barriers to anadromous fish migration. Therefore, any *O. nerka* must be kokanee. It was not surprising that *O. nerka* numbers were low in these lakes, but what was unusual was the absence of stickleback in Batchellor and Whalen lakes. Other stained lakes in this study support significant populations of stickleback in the pelagic zone, whereas these two lakes had no detectable sticklebacks (Table 4). No pelagic stickleback were caught in Red Bluff Lake either, but a few specimens where caught in the littoral zone.

Sampling the pelagic zone of Batchellor Lake with 45 minutes of trawling and four overnight gill net sets, produced only one Dolly Varden, caught in a Swedish gill net. Littoral gear was fished on 11 occasions; two RIC gill nets were set overnight, five minnow traps set overnight and four beach seines completed. The RIC gillnets caught three Dolly Varden and 56 cutthroat trout, minnow traps caught five Dolly Varden and beach seines captured three Dolly Varden and 19 cutthroat trout. No kokanee were caught in Batchellor Lake (Table 3). In spite of the wide variety of gear deployed, only cutthroat trout and Dolly Varden were captured, both predators on smaller fish. The question arises; what were they feeding on, juvenile cutthroat and Dolly Varden, or is there some population of forage fish that was not detected by the sampling gear.

On Red Bluff Lake, seven trawls totaling 138 minutes of fishing time, and three overnight Swedish gill net sets were completed in the pelagic zone. Trawls caught 17 kokanee, 16 of which were age-0 with an average length of 38 mm (Table 3). Swedish gill nets caught seven older kokanee but no age-0s; likely due to the small size of these first year fish and the gill nets not being able to retain them (Table 3). Trawls also caught ten small (10 mm) larval fish and Swedish gill nets also caught three cutthroat trout. In the littoral zone, five RIC gill nets, 11 minnow traps, one dip net, and one beach seine were deployed. The RIC gill nets caught 26 cutthroat trout. Minnow traps caught 122 stickleback along with a few sculpin and cutthroats. The beach seine caught 28 stickleback and six sculpin and the dip net a single sculpin Appendix 2). With three age classes of *O. nerka* detected, there is a viable population of kokanee present in Red Bluff Lake. They, along with stickleback and sculpin, provide a food base for the cutthroat population.

To sample Whalen Lake's pelagic zone, four trawls, for 100 minutes of total fishing time, were conducted, along with four Swedish gill net sets. Each gear caught one age-1 kokanee. In the limnetic region of the lake, four RIC gill nets and eight minnow traps were deployed. The RIC gill nets caught 19 Dolly Varden, one coho salmon and eight age-1 kokanee. Minnow traps caught nine Dolly Varden (Table 6). One Swedish gill net was also deployed near shore to try and catch on-shore juvenile kokanee, but it came up empty. In short, a small kokanee population was detected along with a predator population, consisting of Dolly Varden.

HYDROACOUSTIC ABUNDANCE ESTIMATES

The phantom midge larva, *Chaoborus*, was detected only in stained lakes during this study. Of the ten stained lakes, *Chaoborus* were not found in Keecha and Red Bluff lakes and although detected in Moore Lake, they were not present in sufficient quantities to significantly hamper regular hydroacoustic assessment and analysis. For the remaining seven stained lakes *Chaoborus* densities were high enough to significantly affect acoustic analysis, and Cha-TT techniques were used to collect and analyze the hydroacoustic data (MacLellan and Hume 2010, Appendix 3).

After excluding the hanging lakes because of their lack of access for anadromous fish, the mean *O. nerka* densities were similar for clear and stained lakes, 564 fish/ha and 517 fish/ha respectively, ranging from 23 fish/ha in Kwinageese Lake to 2 613 fish/ha in Meziadin Lake (Table 7). Densities of all small fish in clear (1 291 fish/ha) and stained (1 066 fish/ha) lakes were also similar on average. The one glacially turbid lake in the study had a much lower small fish mean density of 39 fish/ha, all *O. nerka* (Table 7). In stained lakes stickleback dominated the other small fish component, while in most clear lakes a variety of species made up this component. The one exception is Alastair Lake, a clear lake with exceptionally high stickleback densities. If Alastair data were removed from consideration, mean density for clear lake's other small fish, would drop from 727 fish/ha to 88 fish/ha.

DIET

Diet data from this study and from Hume and MacLellan (2008) were pooled for diet analysis using the new water clarity classification scheme presented in this paper. The preferred juvenile *O. nerka* diet consists mainly of zooplankton, and in particular the cladoceran, *Daphnia,* when it is available (Foerster 1968, Hume et al. 1996). Results from this study confirm that zooplankton is the dominant prey type for clear and stained lakes (Fig. 5). *Daphnia* predominate in the juvenile *O. nerka* diet in clear lakes while *Bosmina* and Calanoid copepods predominate in stained lakes (Fig. 6). In glacially turbid lakes, where all Cladocera are largely absent (Lloyd et al, 1987), *O. nerka* diets consisted mainly of Calanoid and Cyclopoid copepods, supplemented with a few terrestrial insects (Figs. 5, 6, 7, 8).

Comparison of the average abundance and biomass of zooplankton, terrestrial insects and macro-invertebrates in the diet for each of the three water types (Fig. 5), shows that while the number of zooplankton consumed in clear and stained lakes is similar, the biomass consumed in stained lakes is roughly 50% that of clear lakes. This reflects the large body size of *Daphnia,* which often dominates sockeye diet in clear water lakes. Consumption of zooplankton in glacially turbid lakes, both in numbers and biomass, is well below that of clear and stained lakes. Terrestrial insects consumed are relatively few in number, however, because of the greater size of the insects relative to zooplankton, they contribute greatly to the biomass consumed (Fig. 5). Insects were the predominant prey type in glacially turbid lakes. Estimates of insect biomass are inaccurate and probably low, and thus most likely underestimate the importance of terrestrial insects in the diet of sockeye in glacially turbid lakes (Hume and MacLellan 2008).

Macro-invertebrates consumed by juvenile sockeye included *Chaoborus* larvae, *Chironomid* larvae, *Ceratopogonid* larvae, *Neomysis*, worms and amphipods. Individually, these organisms would contribute greatly to the biomass consumed by a fish due to their large size. However, they were found only in a few fish from a few of the study lakes and their overall contribution to sockeye diet is fairly small (Fig. 5).

Threespine stickleback were clearly the most common competitors for food with juvenile sockeye in the pelagic zone of the study lakes, particularly in the stained lakes. This is partly because many of the study lakes are on or near the coast where the lakes tend to be stained and threespine stickleback are a coastal species, rarely found far inland (McPhail, 2007). Stickleback were captured by midwater trawl in sufficient numbers to analyze diet data in 12 out of 19 stained lakes, while only one clear lake (Alastair) produced significant numbers of stickleback (Appendix 2, Table 4). Stickleback diet in stained lakes was similar to that of juvenile sockeye (Figs. 6 and 9). In clear Alistair Lake, stickleback also ate the same zooplankton as sockeye, *Bosmina* and cyclopoids (Appendix 5).

Other possible competitor species include whitefish (*Coregonus* spp.), lake chub (*Couesius plumbeus*), and redside shiners (*Richardsonius balteatus*) (McPhail, 2007). Although we did not often encounter these species in significant numbers in the midwater pelagic zones of the study lakes, these species are known to prey on a large variety of organisms and the potential for food competition with juvenile sockeye exists (Hume and MacLellan 2008). Lake chub diet consisted of *Bosmina* and insects, while redside shiners and whitefish primarily consumed insects and macro-invertebrates (Appendix 5).

PLANKTIVORE BIOMASS AND PREDICTED PRODUCTION

DFO's policy for the conservation of wild salmon (DFO 2005) requires the monitoring and assessment of the status of sockeye stocks or conservation units (CUs). One useful tool for determining the current status of a particular sockeye stock CU is to compare the observed biomass of the age-0 juvenile sockeye population from these pelagic surveys with the predicted lake capacity from models of rearing capacity, such as the photosynthetic rate (PR) model (Hume et al. 1996, Shortreed et al. 2000, Cox-Rogers et al. 2004, Hume and MacLellan 2008). The PR model predicts total planktivorous fish biomass but these predictions must be revised downwards if other planktivorous fish species other than age-0 sockeye are present in the pelagic zone and are and competing for the same prey items (Cox-Rogers et al. 2004). We found that potential competitors for the zooplankton resources in these lakes include the pelagic forms of threespine stickleback, whitefish, Dolly Varden, sculpin, coho, and cutthroat trout. Using estimates of abundance and size from the hydroacoustic estimates and the trawl catch, we used these species in the calculation of both juvenile sockeye and potential competitor biomass as required for the model (Table 7).

Biomass of juvenile sockeye and their fish competitors was determined from the hydroacoustic estimates and the mean size of the fish in the trawl catch. If trawl catch data was inadequate, then information from gillnets was used (Table 7). In clear lakes, juvenile sockeye and competitor biomass averaged 1.7 kg/ha and 1.2 kg/ha respectively. In stained lakes, age-0 sockeye and competitor biomass averaged 1.2 kg/ha and 1.0 kg/ha respectively. In both lake types age-0 sockeye averaged 54 - 58% of the total planktivore biomass. In the one glacially turbid lake in this report, Bowser Lake, age-0 biomass was only 0.1 kg/ha and there were no pelagic competitors. It is worth noting however, that the competitor biomass in clear lakes is largely driven by the large stickleback population in Alastair Lake. If we remove Alastair from the analysis, competitor biomass for clear lakes drops two orders of magnitude to .027 kg/ha, while sockeye biomass remains much the same at 1.6 kg/ha, and juvenile sockeye biomass now makes up 98% of total planktivore biomass in clear lakes. This suggests clear lake juvenile sockeye, rearing outside the geographic range of threespine stickleback, which is mostly within 200 km of the coast (McPhail 2007), have very little competition for food resources in the pelagic zone of these lakes. In contrast, sockeye populations that share either stained or clear lakes with threespine stickleback (coastal and near coastal lakes) experience significant competition for food resources. This must be considered when estimating carrying capacity. Hall et al. (In press) used the estimated biomass results to determine the status of the sockeye CUs of the Nass River watershed.

WATER CLARITY SUMMARY

Although there were some inconsistencies, our surveys of 43 lakes in northern British Columbia, this study and Hume and MacLellan (2008), found distinct differences between lake types in species composition, and in juvenile sockeye vertical distribution and diet.

Juvenile sockeye and threespine stickleback were generally the dominant fish species in the pelagic area of the 24 clear and 16 stained lakes (Appendix 2, Hume and MacLellan 2008). Similarly to the lakes in our studies, threespine stickleback were the most common competitor species found in other BC lakes (O'Neill and Hyatt 1987). Other species, such as sculpins, lake chub, redside shiner, and whitefish (Appendix 2), were sometimes captured as well. Unlike the three glacially turbid lakes we surveyed in this study and in Hume and MacLellan (2008), where juvenile sockeye were the only trawl caught fish, Chernoff (1971) found abundant threespine stickleback populations in Owikeno Lake. This difference may be related to the coastal location of Owikeno Lake compared to the inland locations of the other lakes.

Diel vertical migration is well known in juvenile sockeye salmon and is thought to be an adaptation to avoid predation by fish predators (Clarke and Levy 1988, Scheuerell and Schindler 2003). Juvenile sockeye typically spend the day at depths where light conditions preclude visual predation, rise to feed in the epilimnion at dusk and dawn, and spend the night in the upper hypolimnion, generally near the thermocline. In clear lakes, daytime *O. nerka* depths are typically >40 m (Narver 1970, Levy 1990) but can be much shallower in stained and glacially turbid lakes (Chernoff 1971, data on file). In the clear and stained lakes of our studies, sockeye were generally found well below the surface at night (typically 10-30 m deep), usually in the upper hypolimnion, but sockeye in two of the glacially turbid lakes, Motase and Bowser, were found in near surface waters at night and were mostly found near shore in Bowser Lake (data on file, Hume and MacLellan 2008). The third glacially turbid lake, Kitsumkalum, had a turbidity reading (5.5 NTUs) only slightly above our classification threshold for turbid lakes and night time vertical distribution was similar to that seen in clear lakes, with juvenile sockeye found below the thermocline at 10-30 m (Hume and MacLellan 2008).

When available, cladocerans, particularly *Daphnia*, are the preferred prey for juvenile sockeye in many lakes. *Daphnia* is usually abundant and often the dominant macrozooplankter in the clear lakes of these studies (Shortreed et al. 2007). Average *Daphnia* biomass was lower in stained lakes and *Bosmina* was often the most abundant cladoceran. Cladocerans were either absent or very sparse in glacially turbid lakes and the plankton communities in these lakes were usually dominated by the copepod *Diacyclops*. These differences in the macrozooplankton community were reflected in the juvenile sockeye diet where cladocerans were the major dietary item in clear and stained lakes, with *Daphnia* the major food item in clear lakes and the smaller *Bosmina* in stained lakes (Figs. 8 and 9). As expected, there were no cladocerans in the diet of juvenile sockeye in glacially turbid lakes and copepods were the most abundant prey item.

However, terrestrial insects were also relatively abundant in the diet and probably provided the most biomass to juvenile sockeye diet in glacially turbid lakes.

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Table 1. Location and morphological data for each of the study lakes. The number of trawling sections and acoustic transects are shown.

Lake	Region	Water type	Recorded Turbidities (NTU)[a]	Date surveyed	Lat. (°N)	Long. (°W)	Elevation (m)	Surface area (ha)	Mean depth (m)	Max. depth (m)	# of sections	# of transects
Alastair	Coastal Skeena	Clear	1.1	13-Sep-09	54°11'	129°19'	45	686	21	79	2	8
Batchellor	North coast	Stained	0 - 1.3	20-Jul-06	53°36'	129°40'	88	567	66	131	1	7
Bowser	Interior Nass	Glacially turbid	18.2 - 59.6	04-Sep-09	56°27'	129°34'	368	3409	65	116	2	12
Elbow	Interior Bella Coola	Clear[b]	1.5 - 4.8	19-Sep-07	52°05'	125°42'	580	138	13	34	1	7
Fred Wright	Interior Nass	Clear	0.3 - 0.9	09-Sep-09	55°58'	128°45'	597	386	18	42	1	9
Keecha	North coast	Stained	0.1	04-Sep-08	53°18'	129°54'	13	332	16	65	4	12
Kimsquit	North coast	Clear[b]	0.1	12-Sep-07	53°07'	127°24'	358	166	35	75	1	7
Kitlope	North coast	Clear[b]	1.3	15-Sep-07	53°06'	127°47'	13	1170	51	123	1	7
Koeye	Central coast	Stained	0.01	12-Sep-06	51°46'	127°42'	53	450	41	63	2	7
Kooryet	North coast	Stained	0.4	01-Sep-08	53°21'	129°59'	21	509	19	63	3	10
Kwinageese	Interior Nass	Clear	0.3 - 0.9	07-Sep-09	56°03'	128°49'	631	259	18	64	1	8
Lonesome	Interior Bella Coola	Clear[b]	0 - 0.9	08-Sep-07	52°14'	125°43'	483	410	12	41	1	7
Meziadin	Interior Nass	Clear[b]	0.77 - 3.4	17-Sep-09	56°04'	129°18'	246	3599	42	134	2	10
Moore	North coast	Stained	0.2	07-Sep-08	53°25'	129°31'	5	280	22	67	2	11
Morice	Interior Skeena	Clear[b]	3.7	22-Sep-09	54°00'	127°37'	763	9738	*92+*[c]	*154+*[c]	3	10
Namu	Central coast	Stained	0.35	15-Sep-06	51°52'	127°50'	9	317	21	58	2	8
Red Bluff	North coast	Stained	0 - 0.14	23-Jul-06	53°28'	129°36'	36	795	65	199	3	8
Tankeeah (lower)	Central coast	Stained	0.57	18-Sep-06	52°19'	128°16'	7	152	8	29	3	10
Tankeeah (upper)	Central coast	Stained	0.7	19-Sep-06	52°21'	128°16'	11	129	10	32	2	7
Whalen	North coast	Stained	-	26-Jul-06	53°13'	128°56'	120	2131	100	255	2	13

[a] Data on file

[b] Glacially influenced, but generally not turbid (NTU<5)

[c] Bathymetry for Morice is very poor, depths are rough estimates only

Table 2. Fish caught by midwater trawls and gill nets in lakes of different water types. CPUE was determined by dividing total catch of each taxa by total trawling time in each water type. CPUE for gill nets was based on over night sets.

	2x2m Trawl				3x7m Trawl	Swedish gill nets			
	Mean CPUE (catch/hr)				Mean CPUE (catch/hr)	Mean CPUE (catch/set)			
Taxa	Clear	Glacially turbid	Stained	Mean	Clear	Clear	Glacially turbid	Stained	Mean
O. nerka									
Age-0	15.2	5.1	49.4		279.1	0.9	0.6	0.1	
Age-1	3.8	4.3	0.6		132.4	0.9	5.2		
Age-2+		0.6				0.3	1.8		
Adult / jack			0.1				0.2		
Threespine stickleback	58.1		36.7			0.2		0.7	
Sculpin	0.8		0.1						
Sucker							0.1		
Lake chub						0.1			
Northern pikeminnow						0.1			
Redside shiner						1.7			
Whitefish					0.8				
Coho salmon	0.3					0.1	0.4	0.0	
Bull trout						0.0	0.3		
Dolly Varden			0.1						
Cutthroat trout						0.0			
Rainbow trout						0.1			
All fish	78.2	9.9	87.1	62.0	412.3	4.3	8.5	0.8	3.2
# of species captured	4	1	4	5	2	9	4	3	10
N (number of lakes)	7	1	10	18	2	7	1	10	18

Table 3. Catch and size of *O. nerka* caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated.

				Trawl caught *O. nerka*					Gill net caught *O. nerka*				
					Weight (g)		Length (mm)			Weight (g)		Length (mm)	
Lake	Clarity	*O. Nerka* age group	Preservative	N	Mean	95%CI	Mean	95%CI	N	Mean	95%CI	Mean	95%CI
Alastair	Clear	Age 0	Formalin	34	1.74	0.18	54	2.2	1	2.17		58	
			Ethanol 85%	13	1.78	0.18	59	1.8					
				47			55						
		Age 1	Formalin	42	4.76	0.31	76	1.6	2	6	9.02	80	38.1
			Ethanol 85%	7	4.71	0.32	79	1.4					
				49			76						
Bowser	Glacially turbid	Age 0	Formalin	12	1.87	0.55	53	5.5	6	2.2	0.22	58	3.4
			Ethanol 85%	13	1.36	0.32	52	4.4					
				25			52						
		Age 1	Formalin	14	4.36	0.41	71	2.2	62	4.69	0.29	74	1.4
			Ethanol 85%	7	3.02	1.19	68	9.8					
				21			70						
		Age 2+	Formalin	1	11.05		95		21	11.14	2.19	96	5.6
			Ethanol 85%	2	6.02	9.21	85	25.4					
				3			88						
Elbow	Clear[a]	Age 0	Formalin						3	9.22	3.95	88	13.1
			Ethanol 85%	11	5.66	1.65	80	6.3	4	7.34	5.94	86	22.1
									7			87	
		Age 1	Ethanol 85%						1	26.15		134	

Table 3. Catch and size of *O. nerka* caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught *O. nerka*					Gill net caught *O. nerka*				
		O. Nerka		N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	age group	Preservative		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
		Age 2+	Formalin						3	95.93	37.83	192	26.6
			Ethanol 85%						2	82.81	146.82	198	38.1
									5			194	
Fred Wright	Clear	Age 0	Formalin	2	3.51	11.75	65	63.5	2	7.06	10.42	84	50.8
		Age 1	Formalin						4	14.99	17.04	106	32.7
Keecha	Stained	Age 0	Formalin	172	1.96	0.11	55	1					
			Ethanol 85%	20	1.89	0.25	59	2.3					
				192			55						
		Age 1	Formalin	4	5.62	1.67	79	7.2					
Kimsquit	Clear[g]	Age 0	Formalin	13	1.33	0.55	45	6.4	8	4.09	0.77	69	4.8
			Ethanol 85%	20	1.19	0.42	48	6.1					
				33			47						
		Age 1	Formalin						8	6.96	2.05	82	7.6
Kitlope	Clear[g]	Age 0	Formalin	75	1.38	0.11	49	1.3	6	2.42	0.55	59	3.7
			Ethanol 85%	25	1.1	0.13	51	1.9					
				100			50						
		Age 1	Formalin	5	4.6	1.13	73	7.9	17	5.04	0.57	76	2.9

Table 3. Catch and size of *O. nerka* caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught *O. nerka*					Gill net caught *O. nerka*				
					Weight (g)		Length (mm)			Weight (g)		Length (mm)	
Lake	Clarity	*O. Nerka* age group	Preservative	N	Mean	95%CI	Mean	95%CI	N	Mean	95%CI	Mean	95%CI
			Ethanol 85%	5	3.44	0.88	70	5.8					
				10			72						
		Age 2+	Formalin						1	14.68		107	
Koeye	Stained	Age 0	Formalin	36	1.79	0.23	52	2.7					
			Ethanol 85%	34	1.44	0.13	55	1.7					
				70			53						
Kooryet	Stained	Age 0	Formalin	35	2.34	0.41	57	2.9					
			Ethanol 85%	26	1.91	0.26	59	2.5					
				61			58						
		Age 1	Ethanol 85%	1	2.54		67						
Kwinageese	Clear	Age 0	Formalin	1	0.72		38						
		Age 1	Formalin	1	14.11		101						
		Age 2+	Formalin						1	29.13		130	
Lonesome	Clear[8]	Age 0	Formalin	34	1.89	0.24	54	2.1	3	2.93	1.76	62	11.1
			Ethanol 85%	29	1.83	0.42	58	3.2	6	3.19	0.22	70	2.1
				63			56		9			67	
		Age 1	Formalin						1	25.63		127	

Table 3. Catch and size of *O. nerka* caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught *O. nerka*					Gill net caught *O. nerka*				
		O. Nerka		N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	age group	Preservative		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
			Ethanol 85%	3	10.04	5.92	101	19.9					
		Age 2+	Formalin						2	203.6	1001.3	238	565.4
Meziadin	Clear[§]	Age 0	Formalin	381	1.84	0.09	54	0.8					
			Ethanol 85%	60	1.73	0.15	57	1.7					
				441			54						
		Age 1	Formalin	99	9.53	0.5	94	1.5					
			Ethanol 85%	36	8.69	0.87	96	3.2					
				135			95						
Moore	Stained	Age 0	Formalin	62	2.75	0.11	62	0.9					
			Ethanol 85%	20	2.32	0.22	63	2.2					
				82			62						
Morice	Clear[§]	Age 0	Formalin	20	4.12	0.94	70	5.5					
		Age 1	Formalin	2	13.06	7.24	102	38.1					
Namu	Stained	Age 0	Formalin	21	2.12	0.35	54	3.4	1	2.34		59	
			Ethanol 85%	20	1.9	0.44	57	4.2					
				41			55						
Red Bluff	Stained	Age 0	Ethanol 85%	16	0.4	0.12	38	4					

Table 3. Catch and size of *O. nerka* caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught *O. nerka*					Gill net caught *O. nerka*				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	*O. Nerka* age group	Preservative		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
		Age 1	Ethanol 85%	1	7		93		5	11.14	4.59	105	11.6
		Age 2+	Ethanol 85%						2	57.62	3.37	173	31.8
Tankeeah (lower)	Stained	Age 0	Formalin	10	2.35	0.63	57	4.6	1	6.34		80	
			Ethanol 85%	19	2.64	0.42	65	3.5					
				29			62						
Tankeeah (upper)	Stained	Age 0	Ethanol 85%	4	1.94	0.52	60	4.5					
Whalen	Stained	Age 1	Ethanol 85%	1	3.41		74		1	13.25		116	
		Age 1[a]	Ethanol 85%						8	9.34	1.37	100	5.6

[a] - RIC gill net was used.

[§] - glacially influenced, but generally not turbid (NTU<5).

Table 4. Catch and size of other fish species caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated.

				Trawl caught					Gill net caught				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	Species	Preserv.		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
Alastair	Clear	Threespine stickleback	Formalin	353	1.45	0.07	50	1.0	4	2.28	1.27	60	13.1
			Live						1			40	
									5			56	
Batchellor	Stained	Cutthroat trout	Live[a]						56			242	10.0
		Dolly Varden	Live						1			222	
			Live[a]						3			152	59.6
									4			170	
Bowser	Glacially turbid	Adult/jack sockeye	Live						2			516	50.8
		Bull trout	Formalin						1	23.49		121	
			Live						3			347	138.0
									4			291	
		Coho salmon	Formalin						5	14.37	2.74	103	6.2
		Sucker	Formalin						1	24.15		120	
Elbow	Clear[g]	Coho salmon	ethanol	1	9.92		99						
		Northern pikeminnow	Formalin						3	139.27	45.81	223	32.3

Table 4. Catch and size of other fish species caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught					Gill net caught				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	Species	Preserv.		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
		Sculpin	Formalin	5	0.10	0.12	21	7.7					
Fred Wright	Clear	Bull trout	Live						1			555	
		Sculpin	Formalin	2	0.08	0.44	17	31.8					
Keecha	Stained	Adult/jack sockeye	Live	1			380						
		Dolly Varden	Formalin	1	27.78		140						
		Prickly sculpin	Formalin	1	1.98		62						
		Threespine stickleback	Formalin	69	2.25	0.22	63	2.1	1	2.02		66	
Kimsquit	Clear[g]	Sculpin	ethanol	1	0.33		34						
Kitlope	Clear[g]	Coho salmon	Formalin						2	4.94	16.01	71	76.2
		Threespine stickleback	Formalin	2	0.96	4.38	45	69.9	1	1.14		46	
Koeye	Stained	Threespine stickleback	ethanol	1	0.27		31						
Kooryet	Stained	Threespine stickleback	Formalin	44	3.53	0.26	73	2.5	1	4.07		77	

Table 4. Catch and size of other fish species caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught					Gill net caught				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	Species	Preserv.		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
Kwinageese	Clear	Coho salmon	Formalin	4	0.36	0.40	31	10.2					
		Lake chub	Formalin						5	18.52	7.99	115	19.5
		Rainbow trout	Formalin						1	27.05		129	
		Redside shiner	Formalin						55	7.15	0.44	78	1.5
			Live						1			80	
									56			78	
Lonesome	Clear[g]	Cutthroat trout	Live						1			265	
		Rainbow trout	Live						1			331	
		Prickly sculpin	Formalin	3	4.25	5.96	66	28.6					
		Sculpin	Formalin	2	0.31	1.52	31	57.2					
			ethanol	1	0.16		27						
				3			30						
Meziadin	Clear[g]	Whitefish	Formalin	1	22.50		125						

Table 4. Catch and size of other fish species caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught					Gill net caught				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	Species	Preserv.		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
Moore	Stained	Threespine stickleback	Formalin	231	0.77	0.09	38	1.8	20	1.40	0.16	52	1.6
			ethanol	5	1.10	0.79	47	19.0					
				236			38						
Morice	Clear[g]	Whitefish	Formalin	1	6.47		89						
Namu	Stained	Threespine stickleback	Formalin	6	4.45	2.19	76	13.6					
Red Bluff	Stained	Cutthroat trout	Live						3			476	81.8
			Live[a]						26			352	17.3
									29			365	
		Larval fish	ethanol	10			10	1.0					
Tankeeah (lower)	Stained	Threespine stickleback	Formalin	1	0.37		34		1	1.55		51	
			ethanol	1	0.20		29						
				2			32						
		Coho salmon	Formalin						1	8.64		82	
Tankeeah (upper)	Stained	Threespine stickleback	Formalin	7	1.62	0.23	55	1.6					

Table 4. Catch and size of other fish species caught in the trawl and gill nets in the surveyed lakes. Gill nets were small meshed Swedish nets, except where indicated (Continued).

				Trawl caught					Gill net caught				
				N	Weight (g)		Length (mm)		N	Weight (g)		Length (mm)	
Lake	Clarity	Species	Preserv.		Mean	95%CI	Mean	95%CI		Mean	95%CI	Mean	95%CI
Whalen	Stained	Coho salmon	Live[a]						1	42.11		141	
		Dolly Varden	Live[a]						19	39.40	23.92	189	47.8

[a] RIC gillnet used

[g] glacially influenced, but generally not turbid (NTU<5)

Table. 5. Mean length of commonly caught pelagic fish species from sockeye rearing lakes for each water type. Hanging lakes are not included.

Gear		Trawls			Swedish gill nets		
Water type		Clear	Stained	Glacially turbid	Clear	Stained	Glacially turbid
# of Lakes Surveyed		9	7	1	7	7	1
O. nerka, age-0							
	# of lakes	9	7	1	6	2	1
	Length (mm)	57	58	52	71	70	58
	95% CI (mm)	8	3	-	10	21	-
O. nerka, age-1							
	# of lakes	6	3	1	6	1	1
	Length (mm)	91	73	70	101	116	74
	95% CI (mm)	11	7	-	20	-	-
O. nerka, age-2							
	# of lakes	0	0	1	4	0	1
	Length (mm)			88	167		96
	95% CI (mm)			-	59		-
Threespine stickleback							
	# of lakes	2	7	0	2	4	0
	Length (mm)	48	53		51	62	
	95% CI (mm)	5	14		10	12	
Sculpin sp.							
	# of lakes	5	1	0	0	0	0
	Length (mm)	34	62				
	95% CI (mm)	17	-				

Table 6. Size of fish caught with other gears from the surveyed lakes.

Lake	Clarity	Gear	Species	Preservative	N	Weight (g)		Length (mm)	
						Mean	95%CI	Mean	95%CI
Batchellor	Stained	Beach sceine	Cutthroat trout	Formalin	19	3.45	2.3	51	13
			Dolly Varden	Formalin	3	6.36	4.76	79	18.8
		Minnow trap	Dolly Varden	Live	5			121	28.1
Lonesome	Clear	Dip net	Northern pikeminnow	Formalin	1	96.33		193	
			Prickly sculpin	Formalin	1	41.42		135	
Red Bluff	Stained	Beach sceine	Sculpin	Formalin	6	0.23	0.07	28	3.2
			Threespine stickleback	Formalin	28	0.71	0.15	41	2.7
		Dip net	Sculpin	Formalin	1	1.48		53	
		Minnow trap	Sculpin	Formalin	3	1.36	0.5	52	10.3
			Cutthroat trout	Live	1			350	
			Sculpin	Live	1			60	
			Threespine stickleback	Live	122			49	0.8
Whalen	Stained	Minnow trap	Dolly Varden	Live	9			111	9.7

Table 7. Estimated abundance and biomass of juvenile *O. nerka* and dominant competitor fish species in the study lakes. Density estimates from Appendix 3. Size estimates are average weight of formalin preserved juvenile *O. nerka* (age-0, age-1 and sometimes age-2) from Appendix 4.

					All Small	Juvenile *O. nerka*			Competitor Species				Large	Juvenile *O. nerka*	
Lake	Water clarity	Date	Analysis method	Reliability of estimate	fish Density (n/ha)	Density (n/ha)	Size [a] (g)	Biomass (kg/ha)	Dominant species[b]	Density (n/ha)	Size [a] (g)	Biomass (kg/ha)	fish Density (n/ha)	Density (%)	Biomass (%)
Alastair	Clear	13-Sep-09	NTG	Medium	6380	544	3.4	1.855	Stickleback	5836	1.5	8.462	92	9	18
Elbow	Clear	20-Sep-07	TT	Medium	167	153	5.7	0.864	Sculpin, NPM, coho	14	0.1	0.001	100	92	100
Fred Wright	Clear	09-Sep-09	TT	Low	728	118	3.5	0.414	Possibly sculpin	610	0.1	0.049	7	16	89
Kimsquit	Clear	13-Sep-07	NTG	High	784	761	1.3	1.012	Sculpin	23	-	-	138	97	-
Kitlope	Clear	15-Sep-07	TT + Trawl	Low	280	275	1.6	0.435	Stickleback, coho	5	1.0	0.005	9	98	99
Kwinageese	Clear	07-Sep-09	TT	Low	68	23	7.4	0.168	Coho	46	0.4	0.016	14	33	91
Lonesome	Clear	08-Sep-07	NTG	High	496	496	1.9	0.937		0	-	-	24	100	-
Meziadin	Clear	17-Sep-09	NTG	Medium	2616	2613	3.4	8.953	Whitefish	3	22.5	0.063	295	100	99
Morice	Clear	22-Sep-09	TT	Very low	97	93	5.2	0.480	Whitefish	4	6.5	0.027	4	96	95
Mean for clear lakes					1291	564	3.7	1.680		727	4.6	1.232	76	44	58
Keecha	Stained	04-Sep-08	Cha-TT	Medium	1184	727	2.0	1.485	Stickleback	457	2.6	1.191	34	61	55
Koeye	Stained	12-Sep-06	Cha-TT	Medium	1085	1063	1.8	1.903	Stickleback	22	-	-	58	98	-
Kooryet	Stained	01-Sep-08	NTG	High	781	241	2.3	0.564	Stickleback (large)	540	3.5	1.907	16	31	23

Table 7. Estimated abundance and biomass of juvenile *O. nerka* and dominant competitor fish species in the study lakes. Density estimates from Appendix 3. Size estimates are average weight of formalin preserved juvenile *O. nerka* (age-0, age-1 and sometimes age-2) from Appendix 4 (Continued).

					All Small	Juvenile *O. nerka*			Competitor Species				Large	Juvenile *O. nerka*	
Lake	Water clarity	Date	Analysis method	Reliability of estimate	fish Density (n/ha)	Density (n/ha)	Size [a] (g)	Biomass (kg/ha)	Dominant species[b]	Density (n/ha)	Size [a] (g)	Biomass (kg/ha)	fish Density (n/ha)	Density (%)	Biomass (%)
Moore	Stained	07-Sep-08	NTG	Medium	2364	229	2.8	0.631	Stickleback	2134	0.8	1.643	5	10	28
Namu	Stained	15-Sep-06	Cha-TT	Medium	628	548	2.1	1.161	Stickleback	80	4.5	0.357	87	87	76
Tankeeah (lower)	Stained	18-Sep-06	Cha-TT	Medium	514	479	2.7	1.300	Stickleback	35	0.4	0.013	141	93	99
Tankeeah (upper)	Stained	19-Sep-06	Cha-TT	Medium	907	330	-	-	Stickleback	577	1.6	0.934	26	36	-
Mean for stained lakes					1066	517	2.3	1.174		549	2.2	1.008	52	48	54
Bowser	Glacially turbid	04-Sep-09	TT & Trawl	Very low	39	39	3.5	0.136		0		0.000	0	100	100
Hanging lakes															
Batchellor	Stained	21-Jul-06	Cha-TT	Medium	150	0	-	-	Cutthroat, Dolly	150	-	-	26	0	-
Red Bluff	Stained	23-Jul-06	TT	High	166	166	-	-		0	-	0.000	46	100	-
Whalen	Stained	26-Jul-06	Cha-TT	Medium	74	74	-	-		0	-	-	101	100	-

[a] average weight of formalin preserved fish caught in trawls

[b] NPM (Northern pikeminnow), stickleback (threespine stickleback), cutthroat (cutthroat trout), Dolly (Dolley Varden)

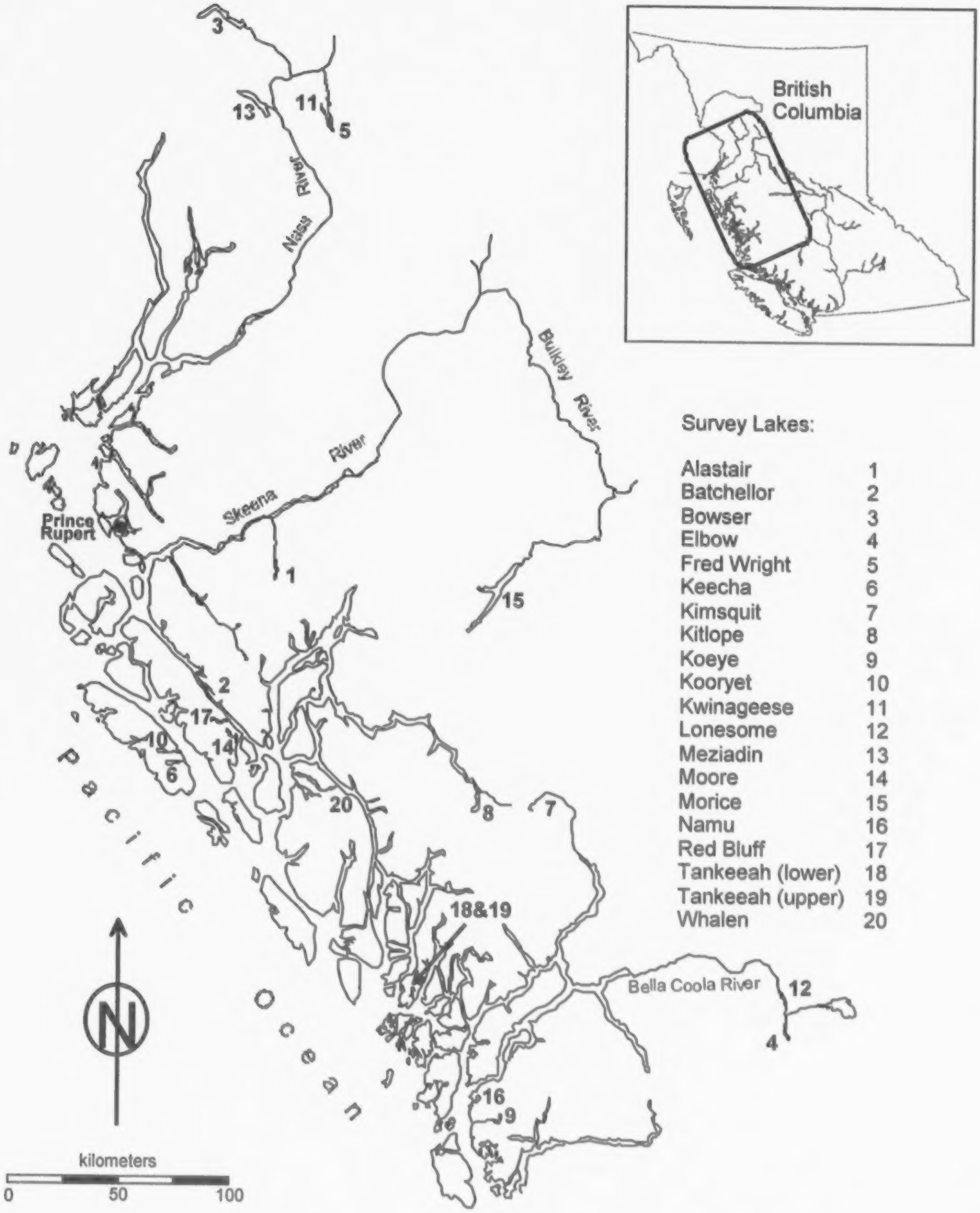

British Columbia
Survey Lakes:
Alastair 1
Batchellor 2
Bowser 3
Elbow 4
Fred Wright 5
Keecha 6
Kimsquit 7
Kitlope 8
Koeye 9
Kooryet 10
Kwinageese 11
Lonesome 12
Meziadin 13
Moore 14
Morice 15
Namu 16
Red Bluff 17
Tankeeah (lower) 18
Tankeeah (upper) 19
Whalen 20
Nass River
Skeena River
Bulkley River
Bella Coola River
Prince Rupert
Pacific Ocean
N
kilometers
0
50
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18&19
20

Fig. 1. Overview map of study region showing the location of the surveyed lakes.

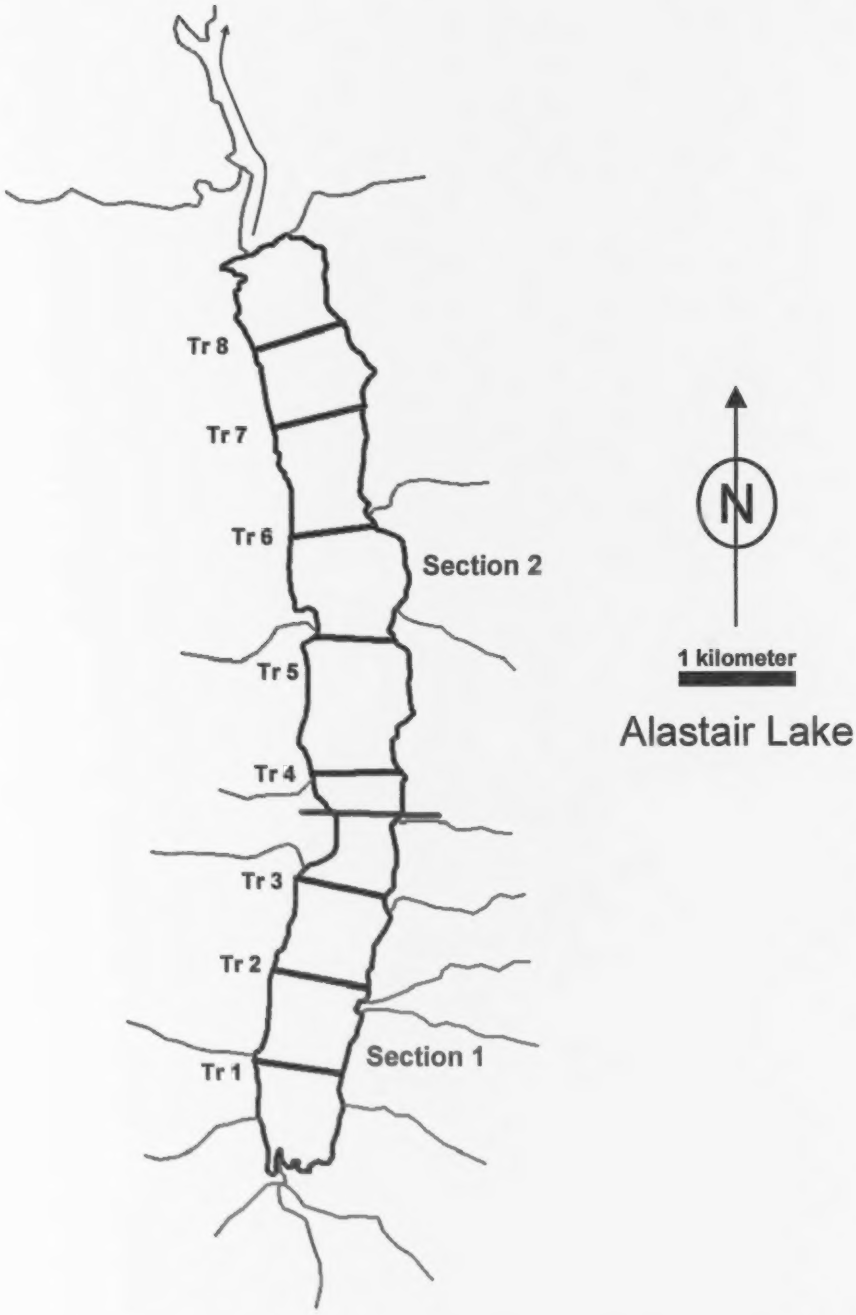

Tr 8
Tr 7
Tr 6
Section 2
Tr 5
Tr 4
Tr 3
Tr 2
Tr 1
Section 1
N
1 kilometer
Alastair Lake

Fig. 2a. Map of Alastair Lake showing the trawl sections and hydroacoustic transects.

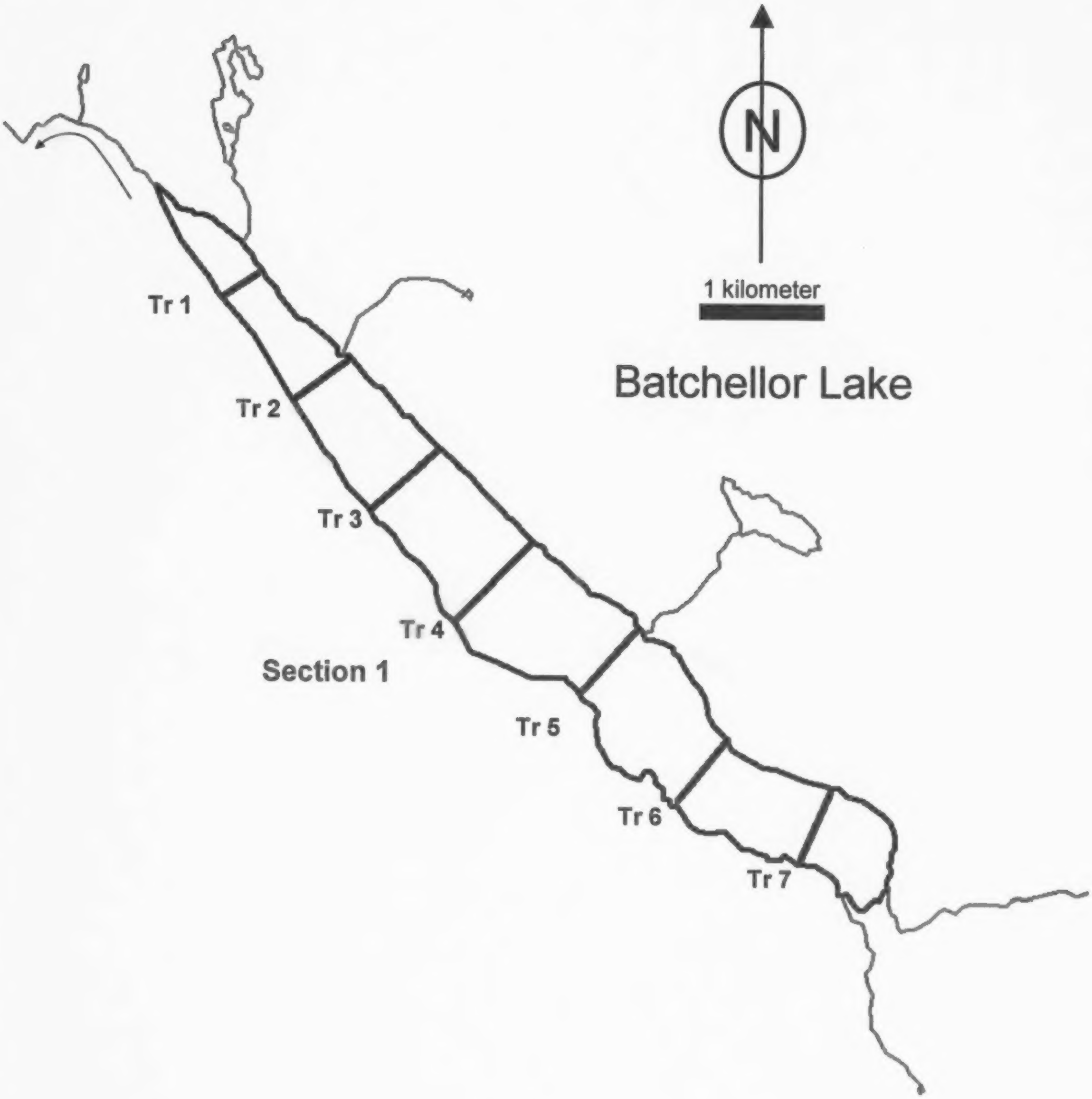

1 kilometer
Batchellor Lake
N
Tr 1
Tr 2
Tr 3
Tr 4
Section 1
Tr 5
Tr 6
Tr 7

Fig. 2b. Map of Batchellor Lake showing the trawl sections and hydroacoustic transects.

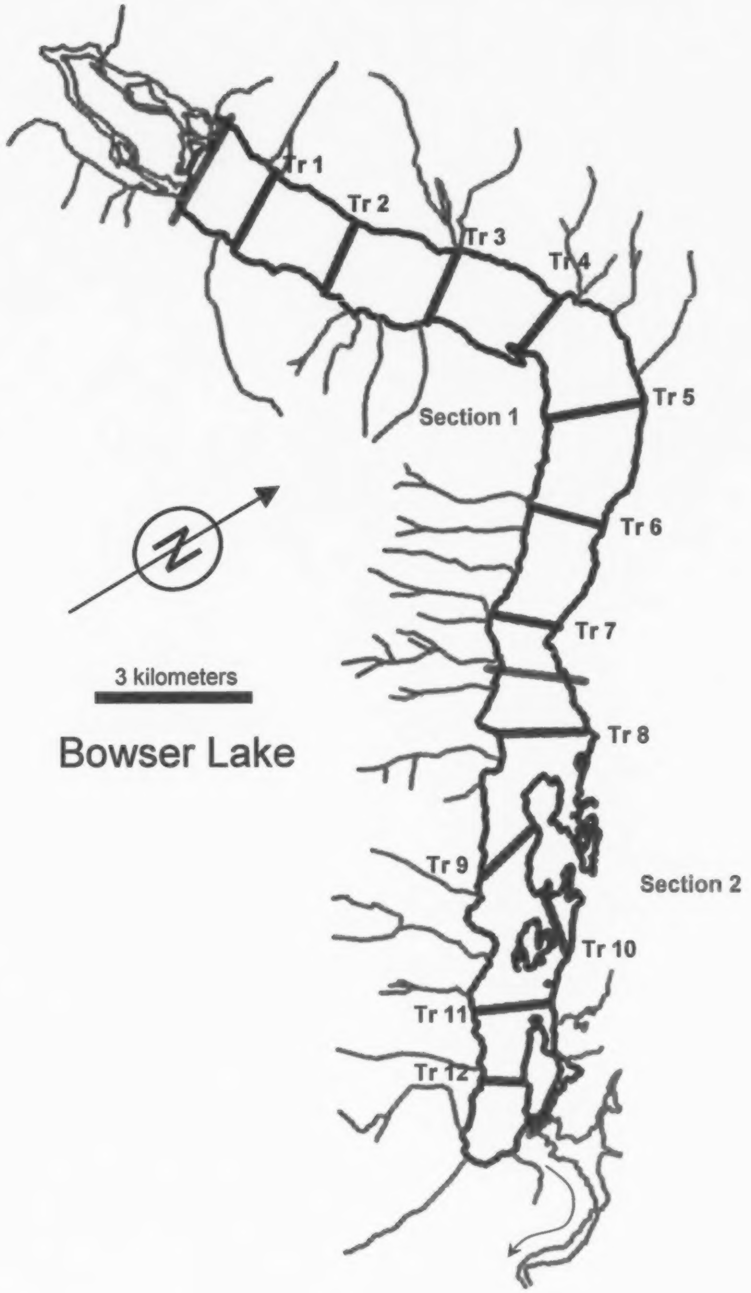

Tr 1
Tr 2
Tr 3
Tr 4
Tr 5
Section 1
Tr 6
Tr 7
3 kilometers
Tr 8
Bowser Lake
Tr 9
Section 2
Tr 10
Tr 11
Tr 12

Fig. 2c. Map of Bowser Lake showing the trawl sections and hydroacoustic transects.

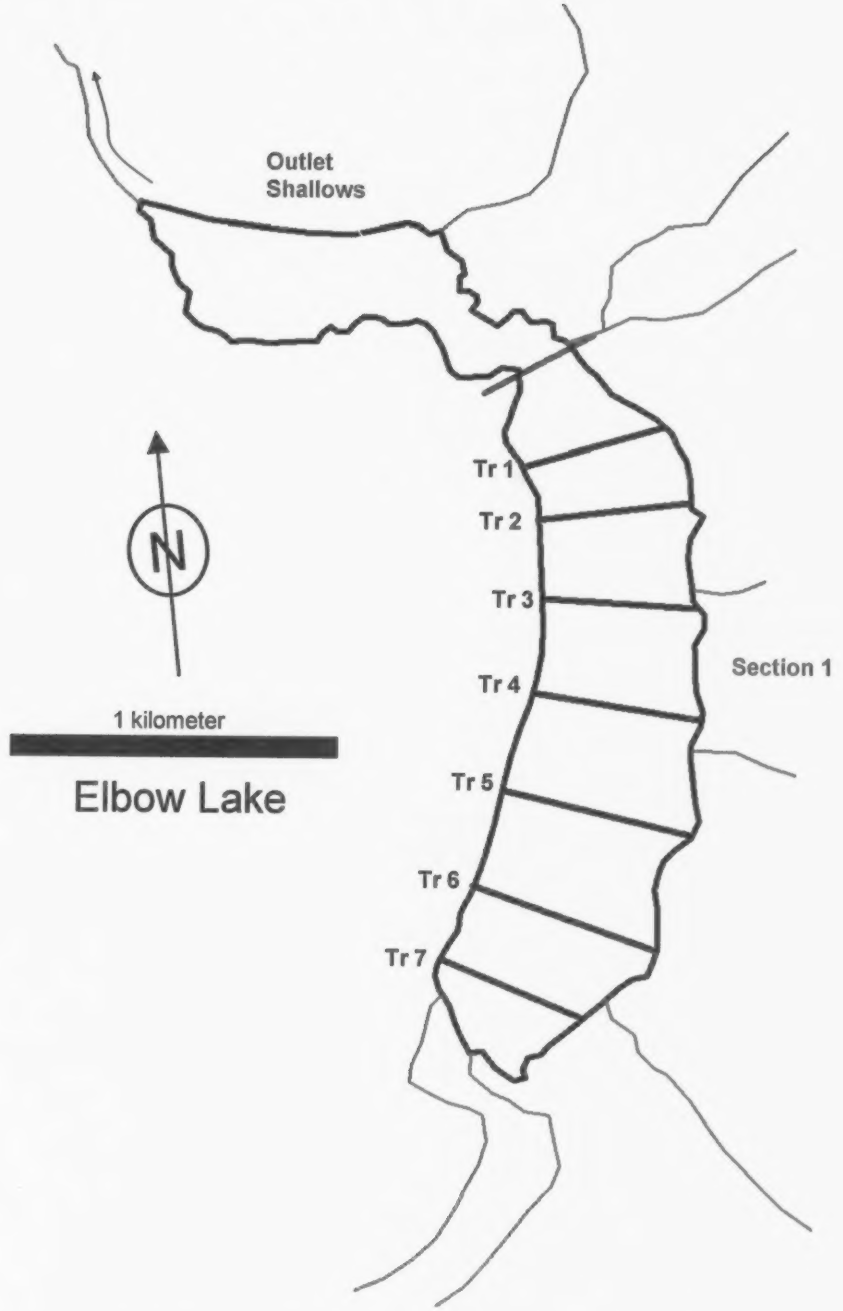

Outlet
Shallows
Tr 1
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Section 1
N
1 kilometer
Elbow Lake

Fig. 2d. Map of Elbow Lake showing the trawl sections and hydroacoustic transects.

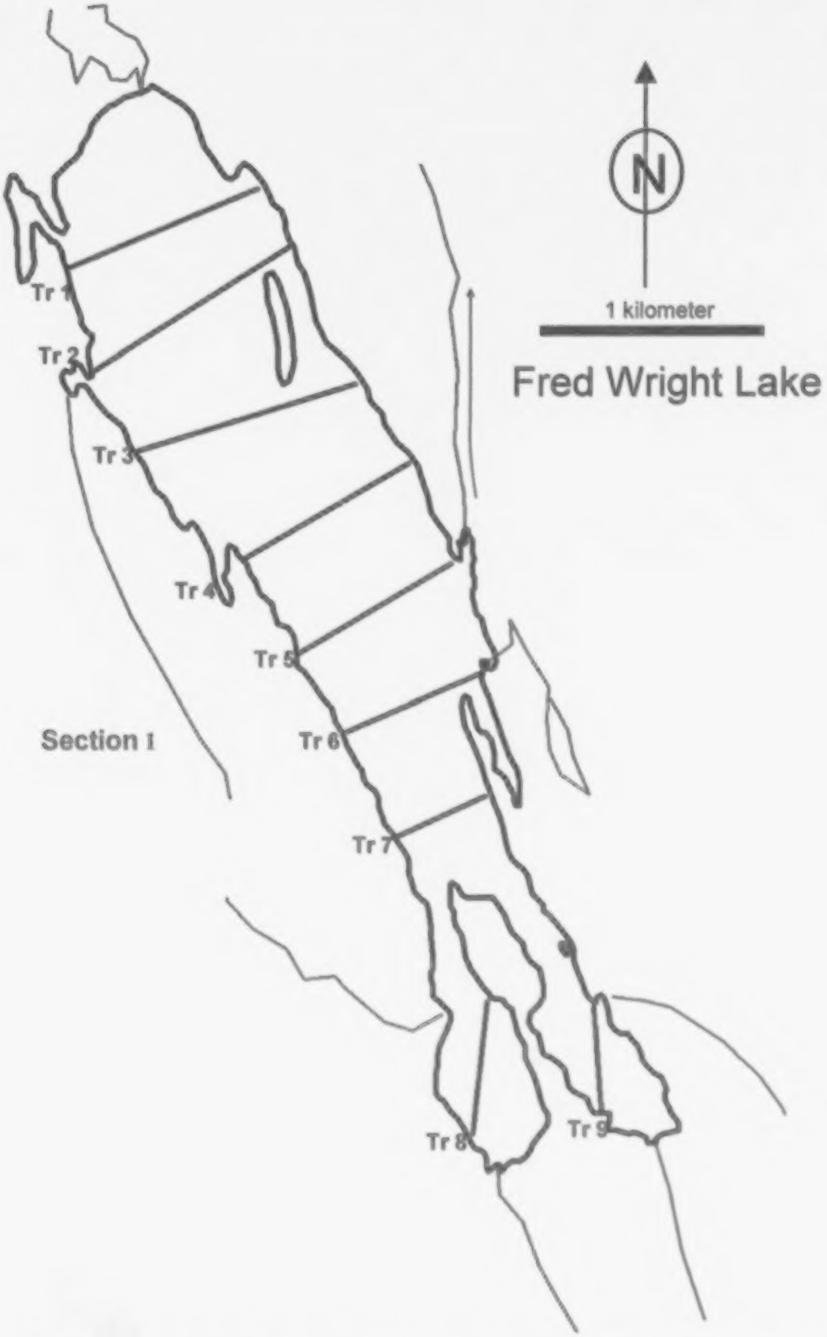

Tr 1
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Tr 8
Tr 9
Section 1
N
1 kilometer
Fred Wright Lake

Fig. 2e. Map of Fred Wright Lake showing the trawl sections and hydroacoustic transects.

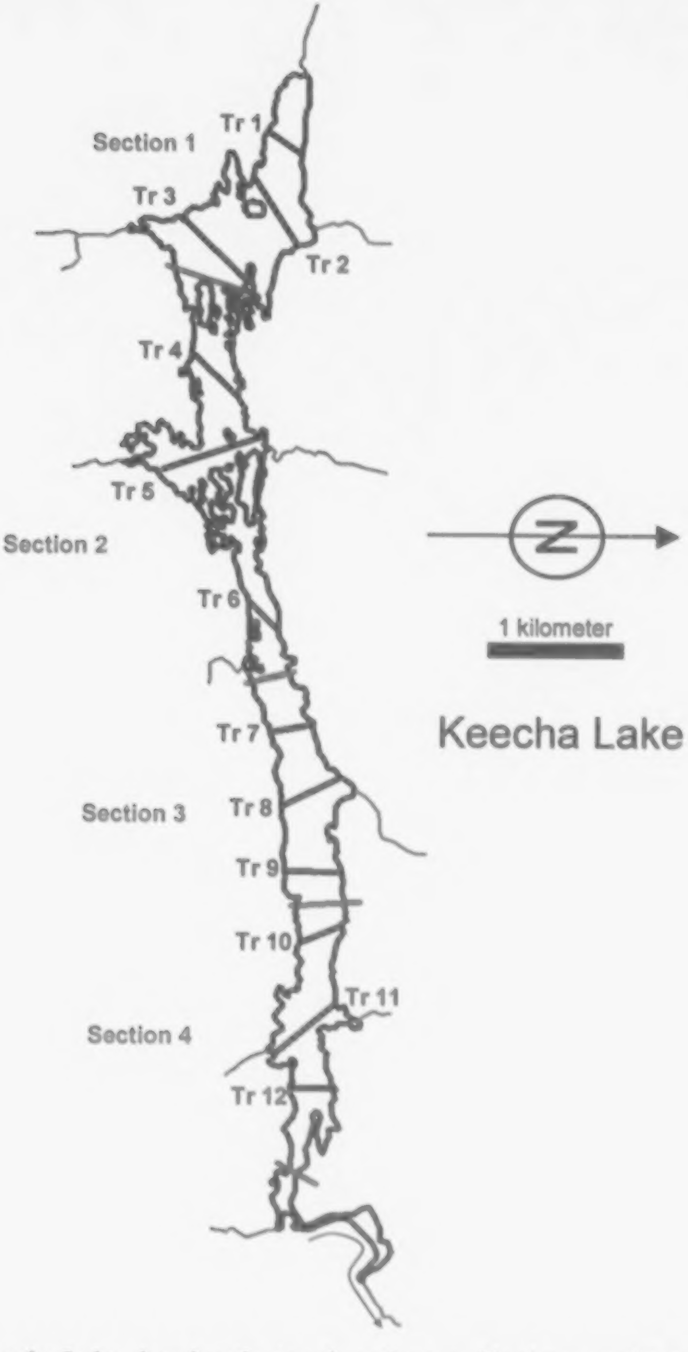

Section 1
Tr 1
Tr 3
Tr 2
Tr 4
Tr 5
Section 2
N
1 kilometer
Tr 6
Keecha Lake
Tr 7
Section 3
Tr 8
Tr 9
Tr 10
Tr 11
Section 4
Tr 12

Fig. 2f. Map of Keecha Lake showing the trawl sections and hydroacoustic transects.

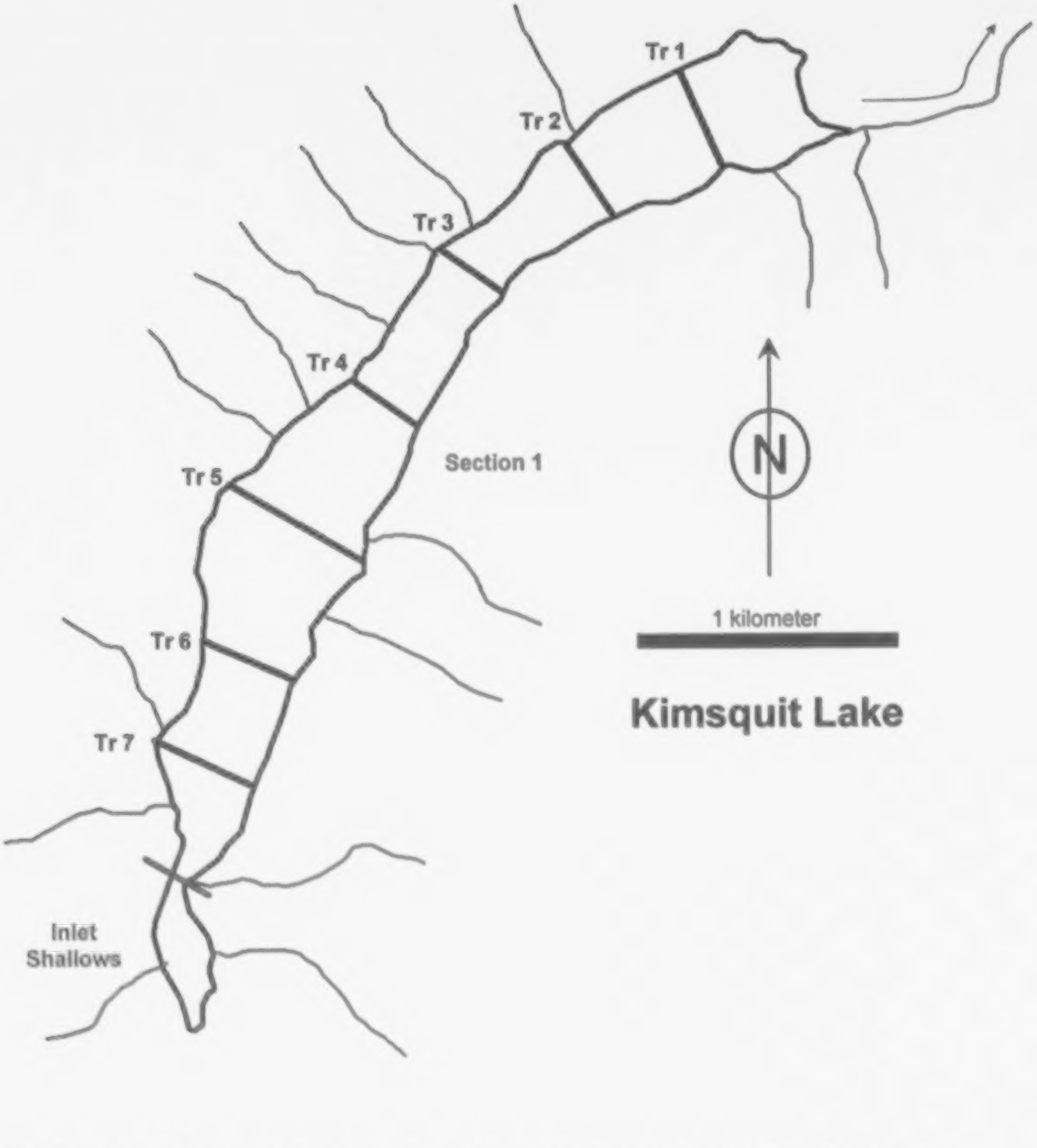

Tr 1
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Section 1
Inlet
Shallows
N
1 kilometer
Kimsquit Lake

Fig. 2g. Map of Kimsquit Lake showing the trawl sections and hydroacoustic transects.

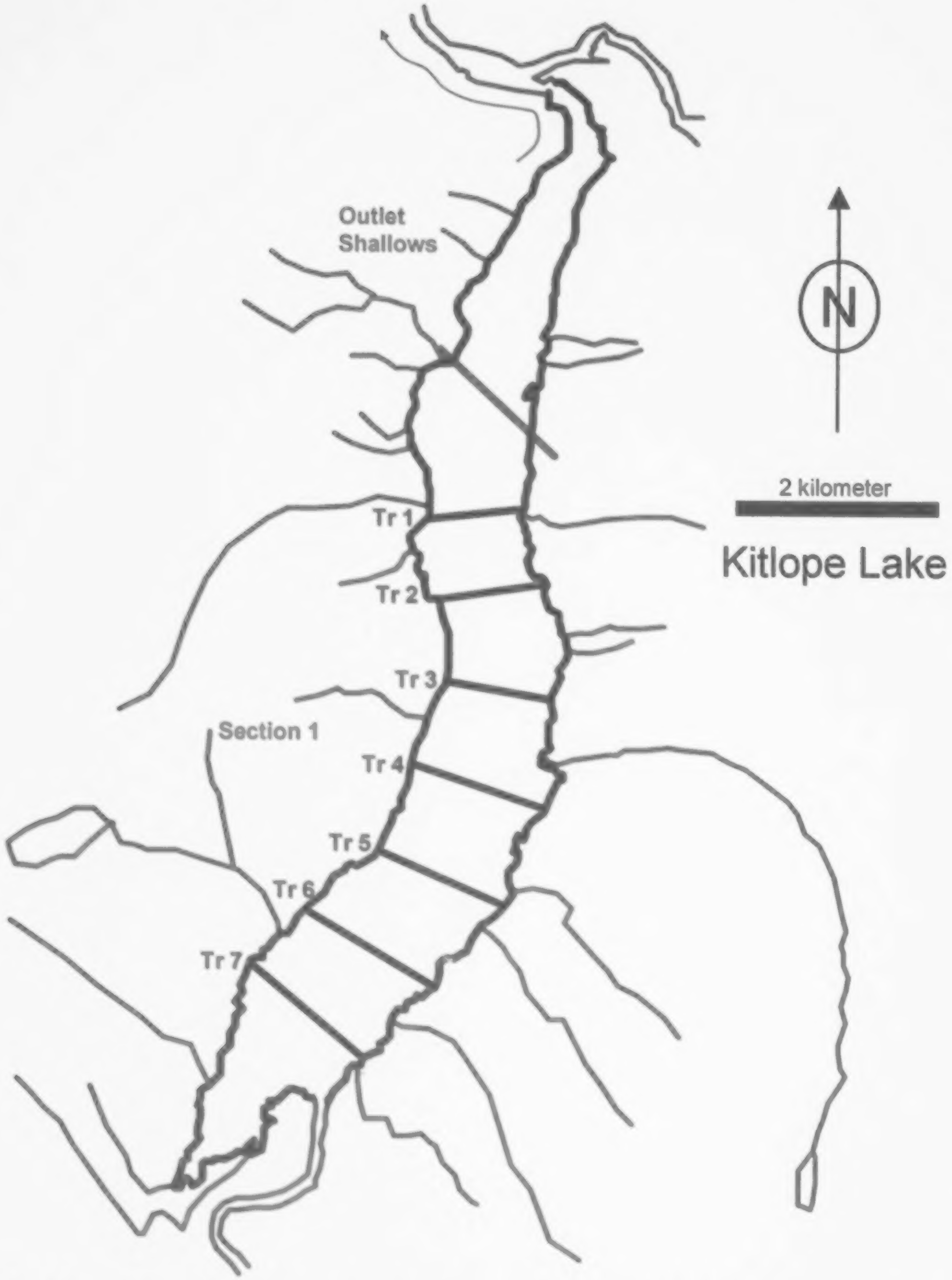

Outlet Shallows
Tr 1
Tr 2
Tr 3
Section 1
Tr 4
Tr 5
Tr 6
Tr 7
N
2 kilometer
Kitlope Lake

Fig. 2h. Map of Kitlope Lake showing the trawl sections and hydroacoustic transects.

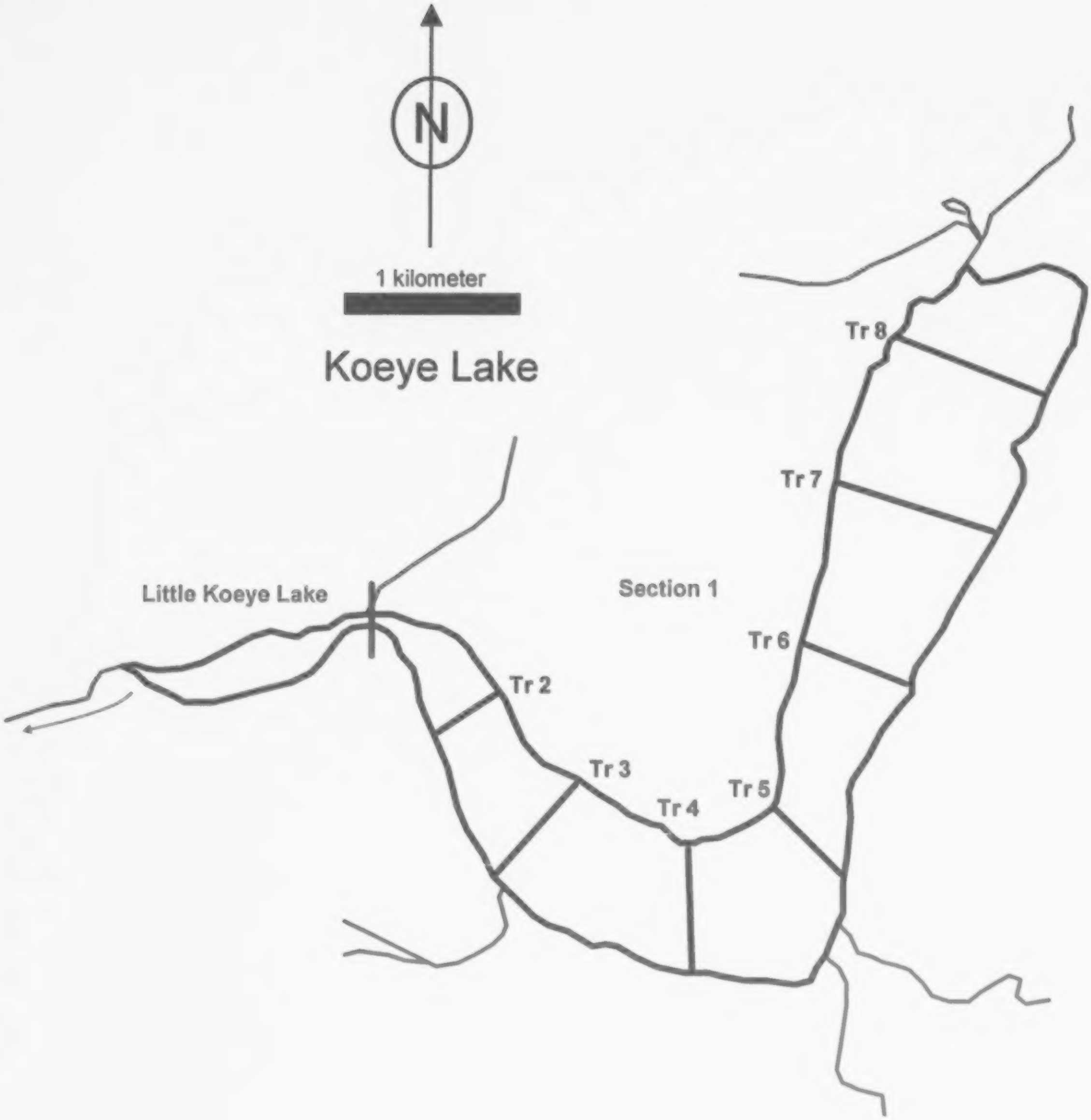

1 kilometer
N
Koeye Lake
Little Koeye Lake
Section 1
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Tr 8

Fig. 2i. Map of Koeye Lake showing the trawl sections and hydroacoustic transects.

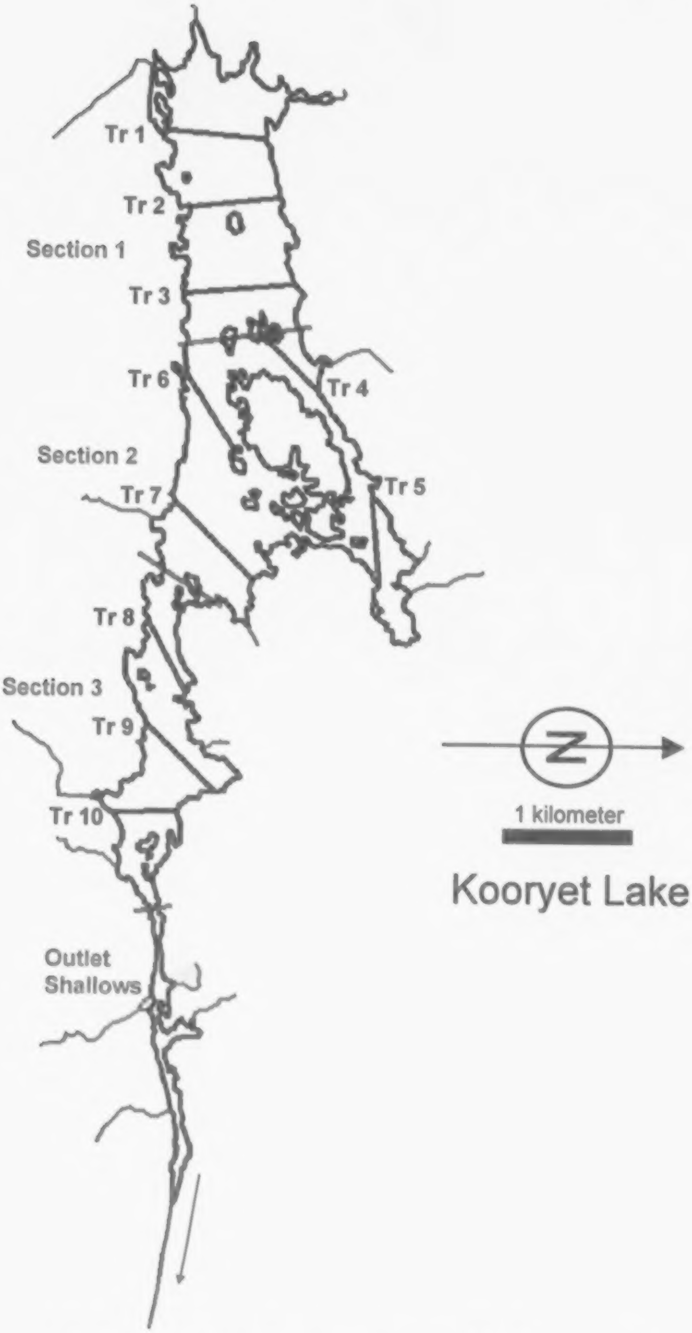

Tr 1
Tr 2
Section 1
Tr 3
Tr 6
Tr 4
Section 2
Tr 7
Tr 5
Tr 8
Section 3
Tr 9
Tr 10
Outlet
Shallows
N
1 kilometer
Kooryet Lake

Fig. 2j. Map of Kooryet Lake showing the trawl sections and hydroacoustic transects.

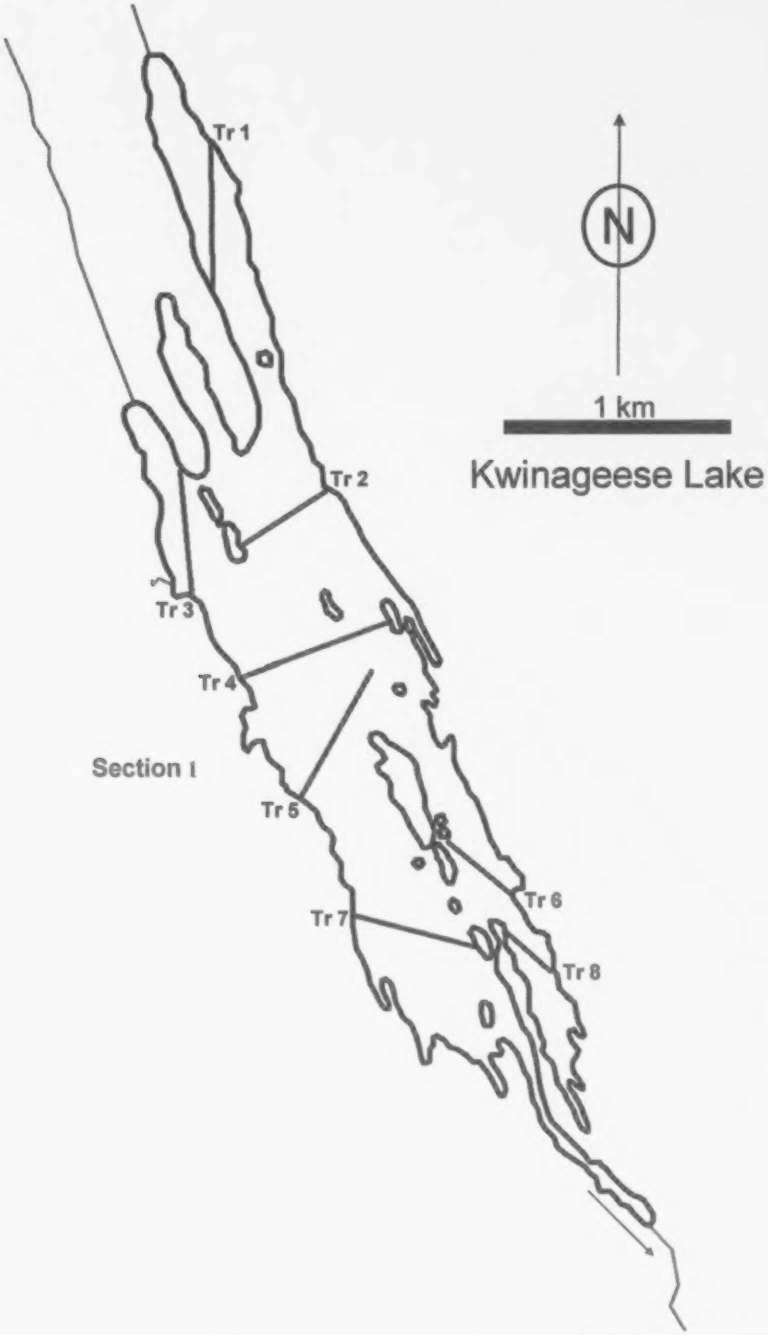

Tr 1
Tr 2
Tr 3
Tr 4
Section 1
Tr 5
Tr 6
Tr 7
Tr 8
N
1 km
Kwinageese Lake

Fig. 2k. Map of Kwinageese Lake showing the trawl sections and hydroacoustic transects.

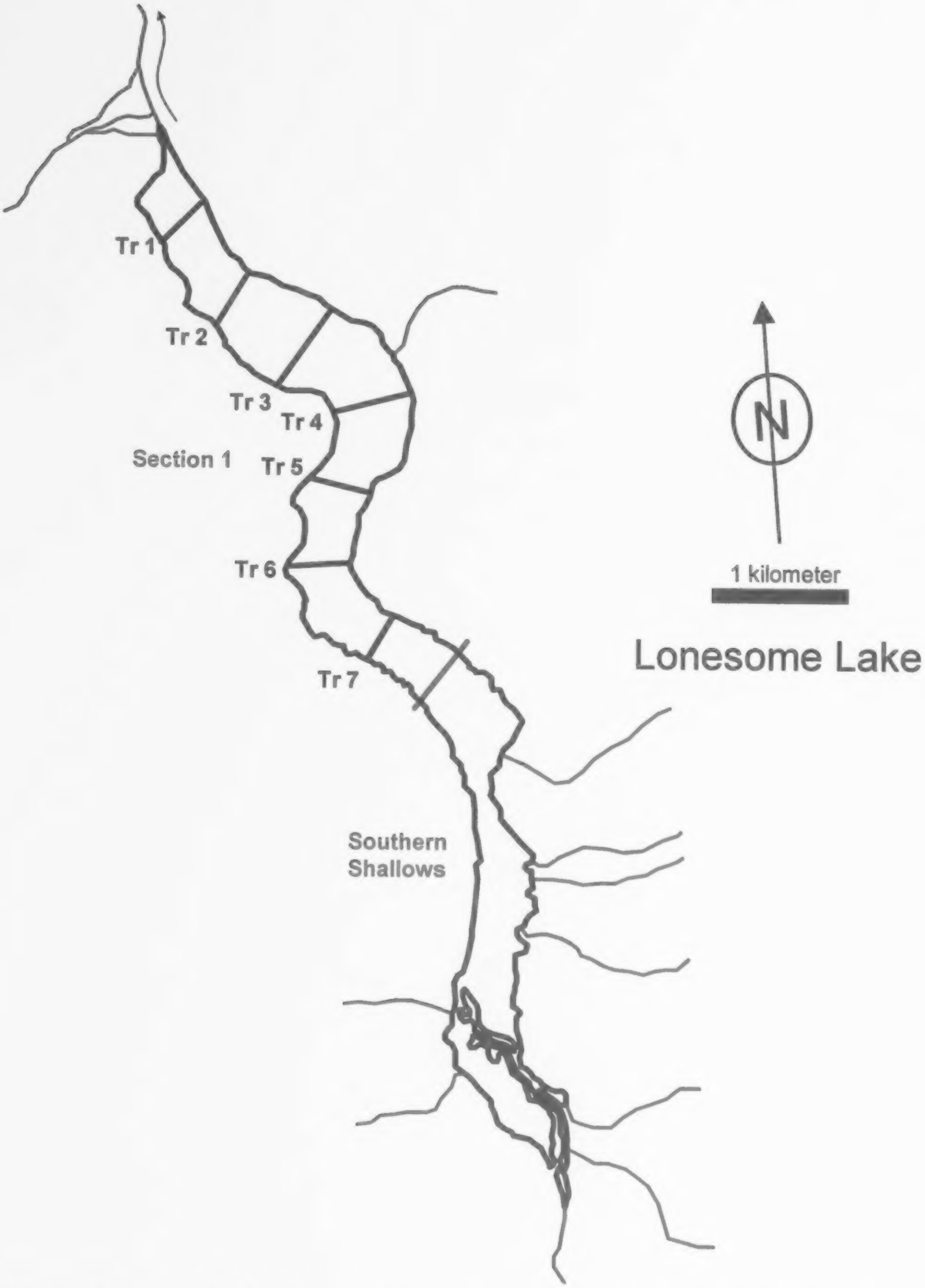

Tr 1
Tr 2
Tr 3
Tr 4
Section 1
Tr 5
Tr 6
Tr 7
Southern Shallows
N
1 kilometer
Lonesome Lake

Fig. 21. Map of Lonesome Lake showing the trawl sections and hydroacoustic transects.

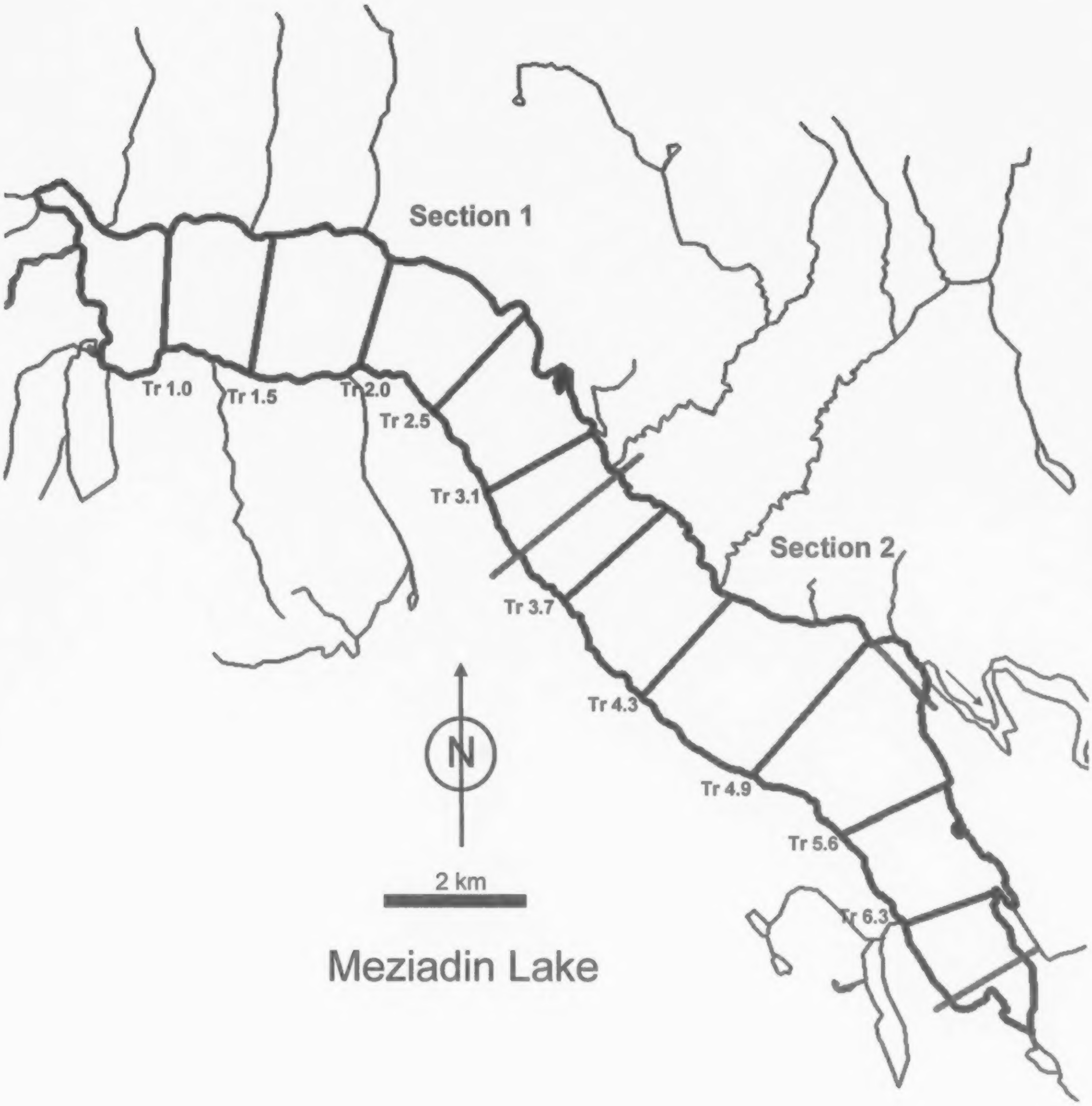

Section 1
Tr 1.0
Tr 1.5
Tr 2.0
Tr 2.5
Tr 3.1
Tr 3.7
Section 2
Tr 4.3
Tr 4.9
Tr 5.6
Tr 6.3
N
2 km
Meziadin Lake

Fig. 2m. Map of Meziadin Lake showing the trawl sections and hydroacoustic transects.

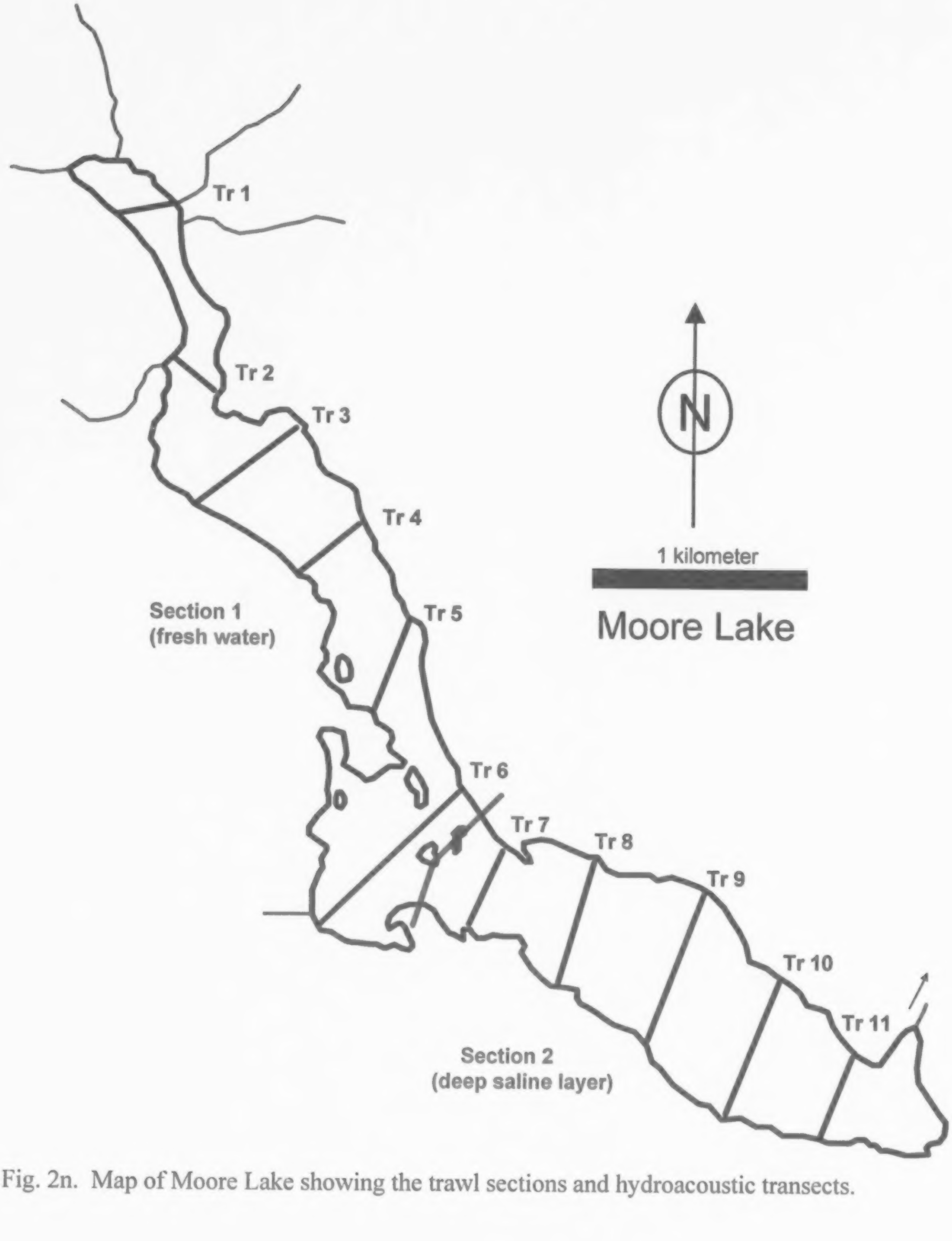

Tr 1
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Tr 8
Tr 9
Tr 10
Tr 11
Section 1
(fresh water)
Section 2
(deep saline layer)
N
1 kilometer
Moore Lake

Fig. 2n. Map of Moore Lake showing the trawl sections and hydroacoustic transects.

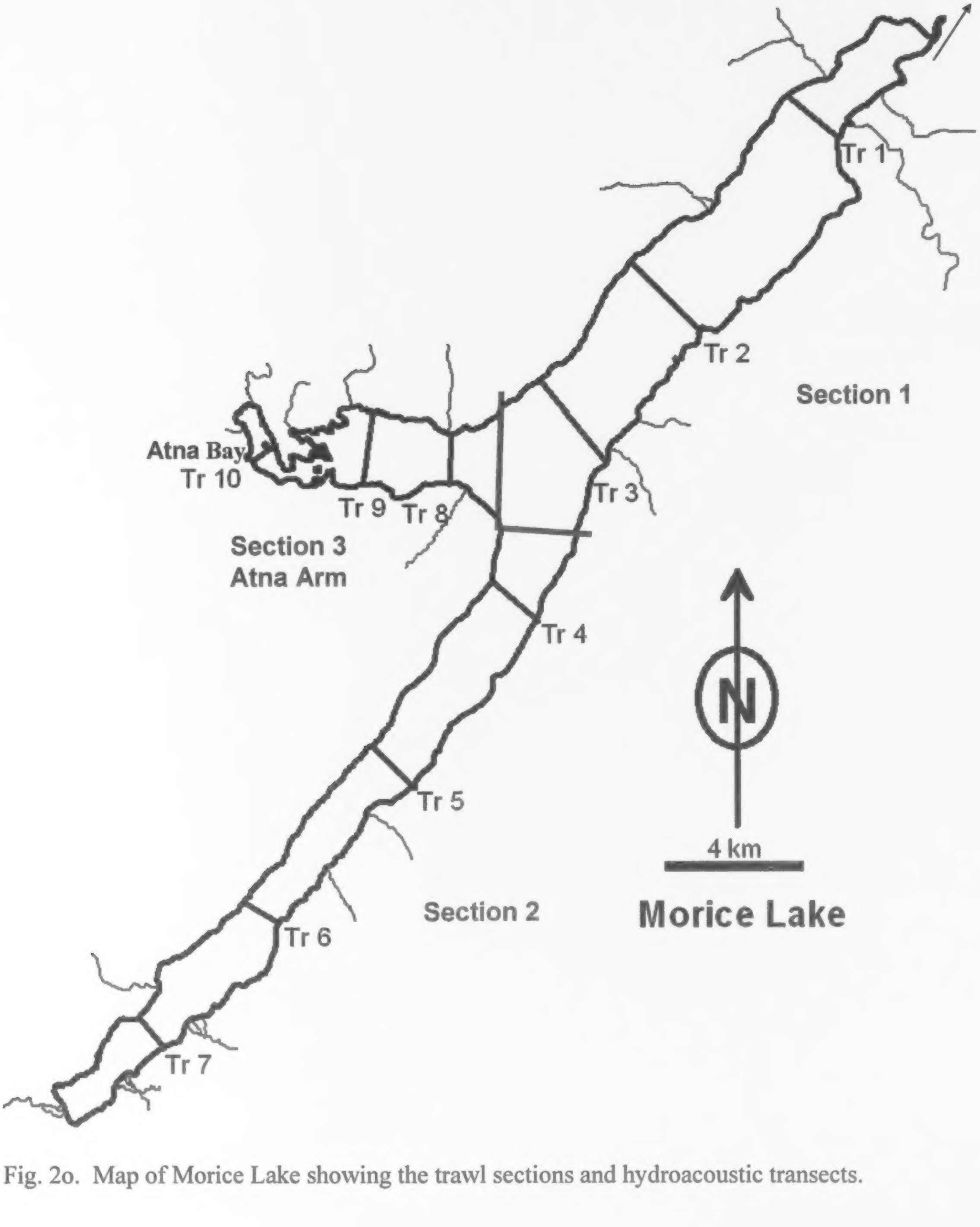

Tr 1
Tr 2
Section 1
Atna Bay
Tr 10
Tr 9
Tr 8
Tr 3
Section 3
Atna Arm
Tr 4
N
Tr 5
4 km
Section 2
Morice Lake
Tr 6
Tr 7

Fig. 2o. Map of Morice Lake showing the trawl sections and hydroacoustic transects.

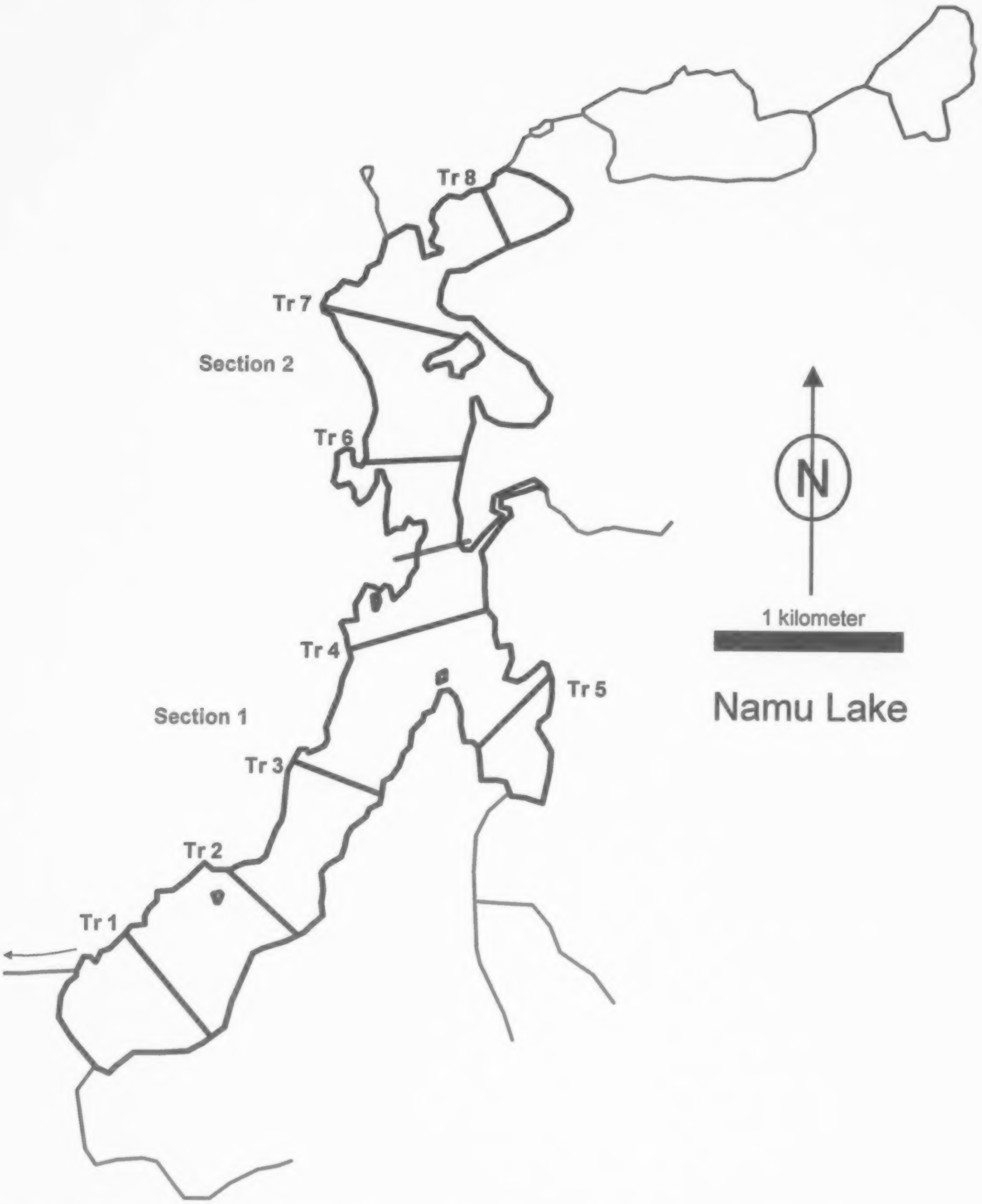

Tr 8
Tr 7
Section 2
Tr 6
Tr 4
Section 1
Tr 5
Tr 3
Tr 2
Tr 1
N
1 kilometer
Namu Lake

Fig. 2p. Map of Namu Lake showing the trawl sections and hydroacoustic transects.

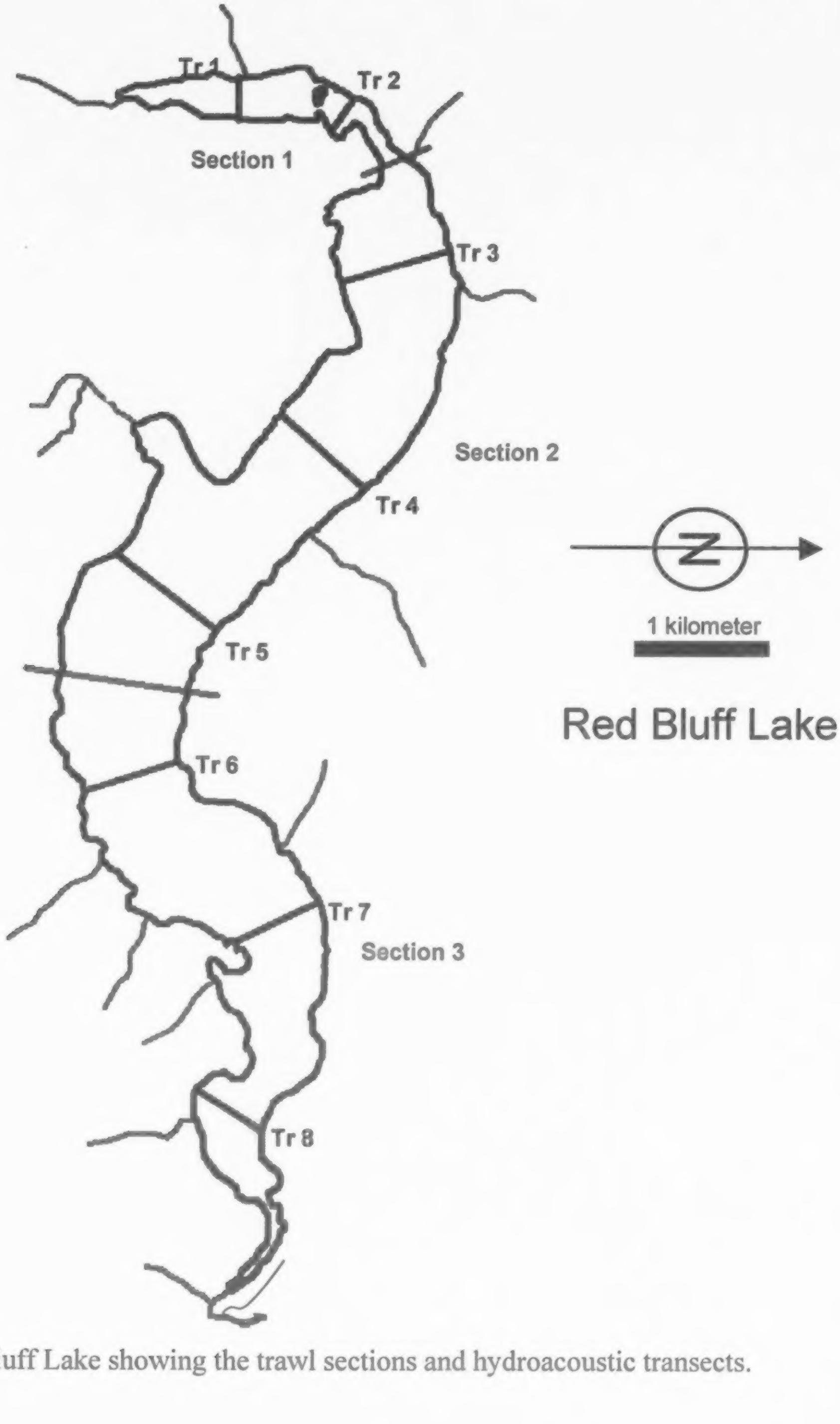

Tr 1
Tr 2
Section 1
Tr 3
Section 2
Tr 4
N
1 kilometer
Tr 5
Red Bluff Lake
Tr 6
Tr 7
Section 3
Tr 8

Fig. 2q. Map of Red Bluff Lake showing the trawl sections and hydroacoustic transects.

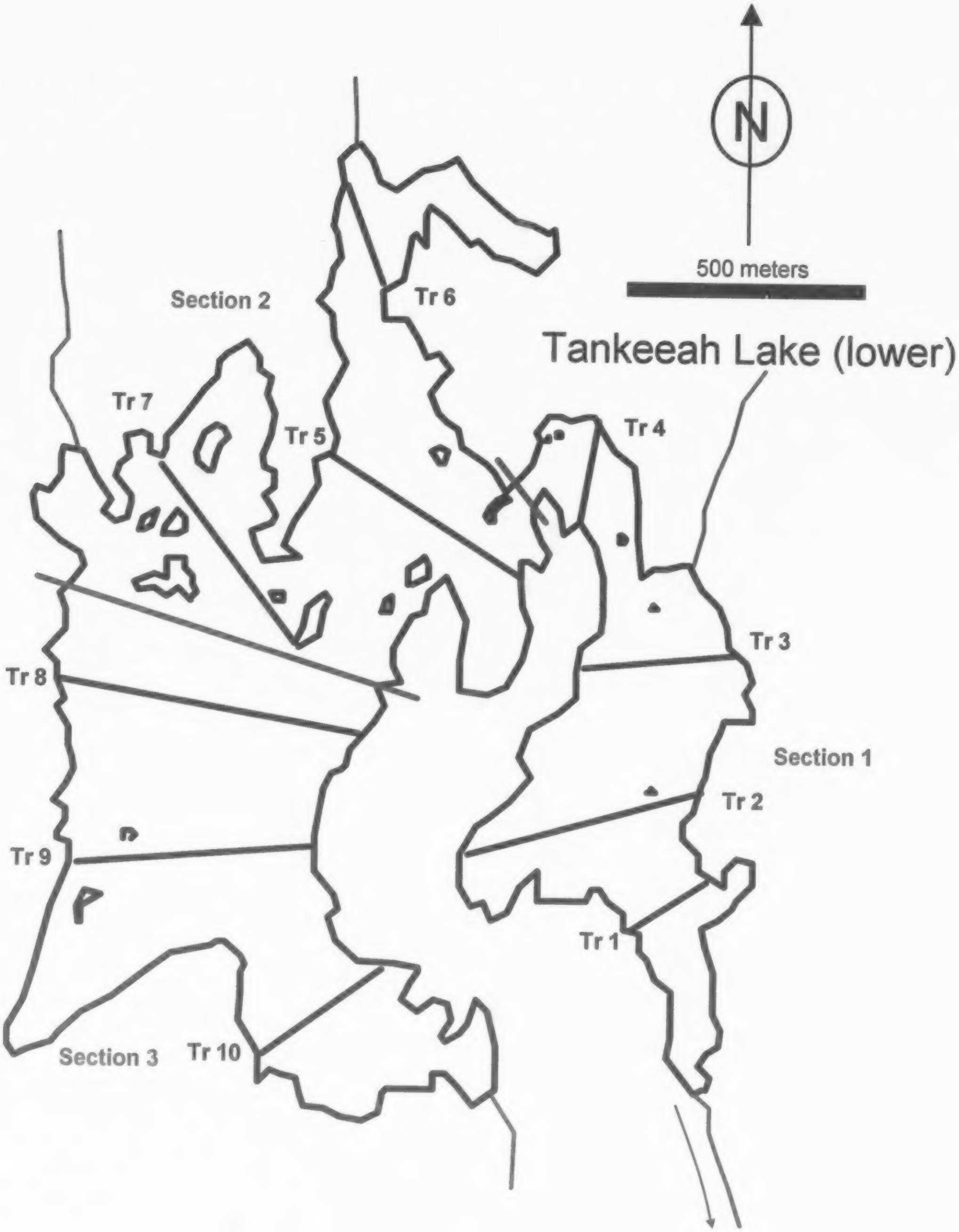

500 meters
Tankeeah Lake (lower)
Section 2
Tr 6
Tr 7
Tr 5
Tr 4
Tr 3
Tr 8
Section 1
Tr 2
Tr 9
Tr 1
Section 3
Tr 10

Fig. 2r. Map of Tankeeah Lake (lower) showing the trawl sections and hydroacoustic transects.

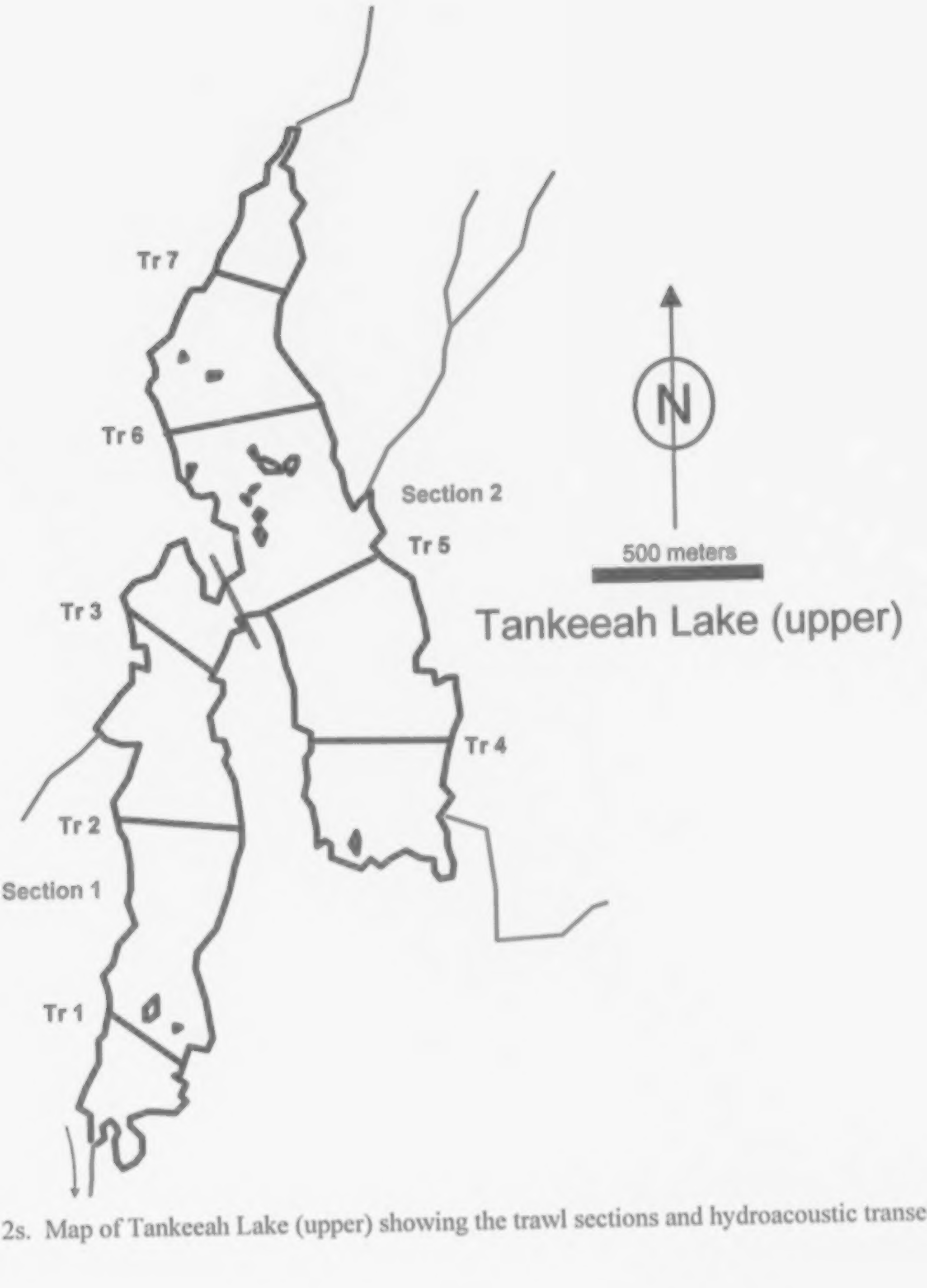

Tr 7
Tr 6
Section 2
Tr 5
Tr 3
Tr 4
Tr 2
Section 1
Tr 1
N
500 meters
Tankeeah Lake (upper)

Fig. 2s. Map of Tankeeah Lake (upper) showing the trawl sections and hydroacoustic transects.

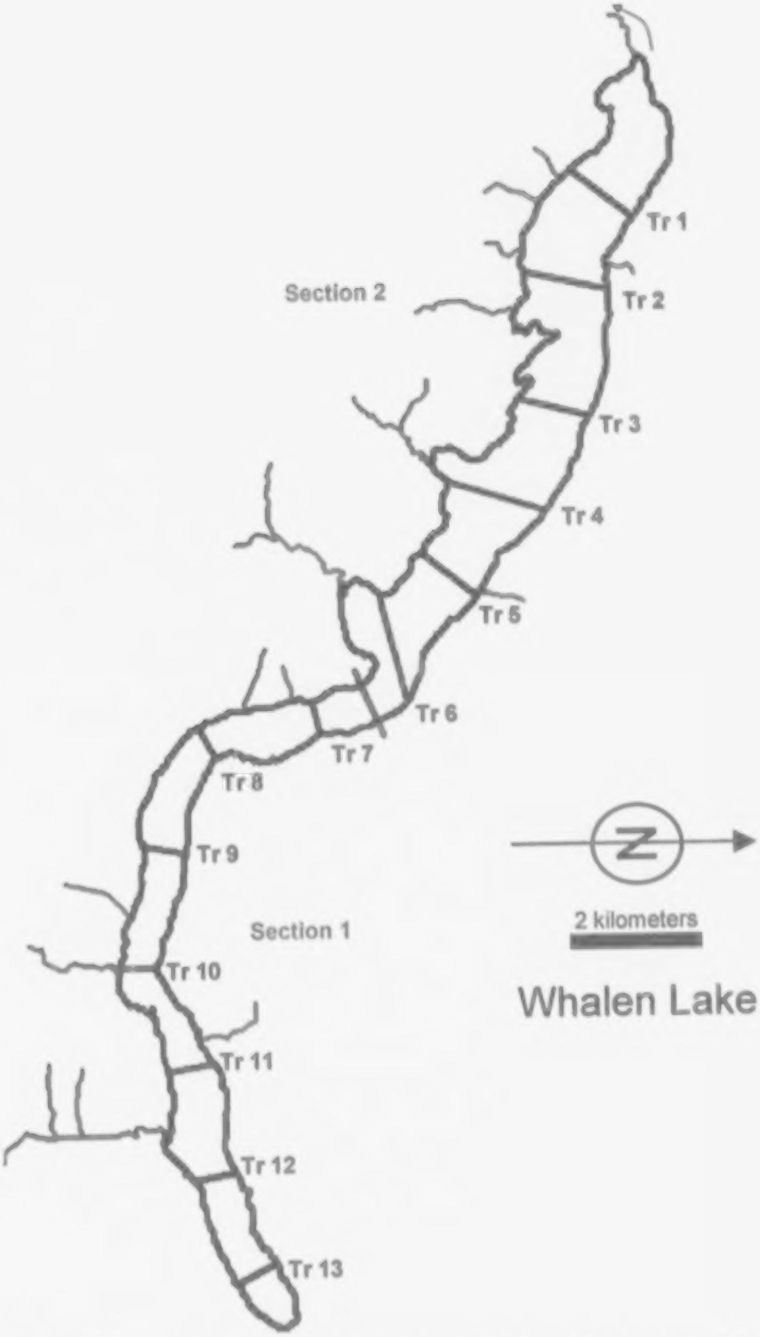
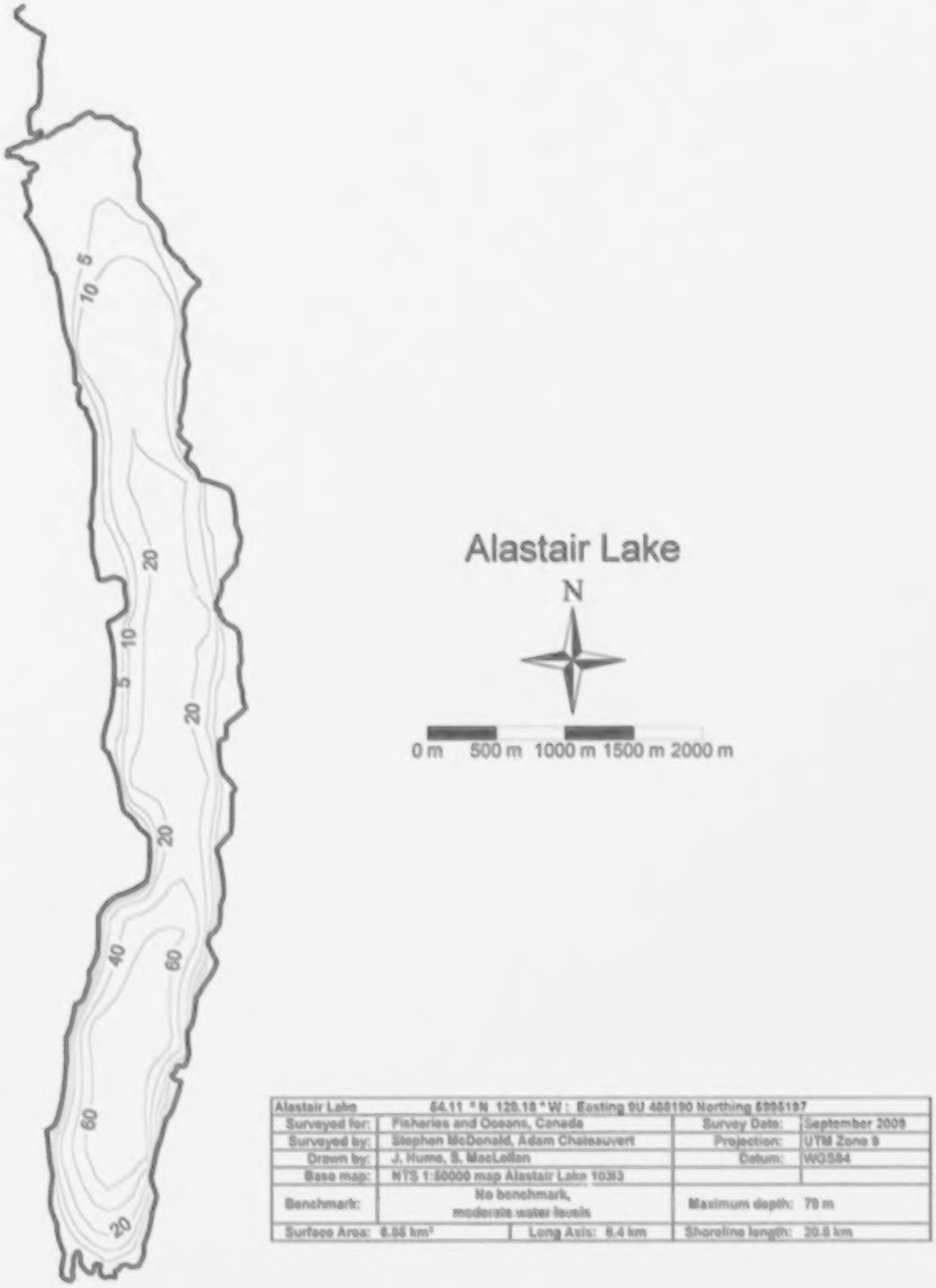

Tr 1
Section 2
Tr 2
Tr 3
Tr 4
Tr 5
Tr 6
Tr 7
Tr 8
Tr 9
N
Section 1
2 kilometers
Tr 10
Whalen Lake
Tr 11
Tr 12
Tr 13

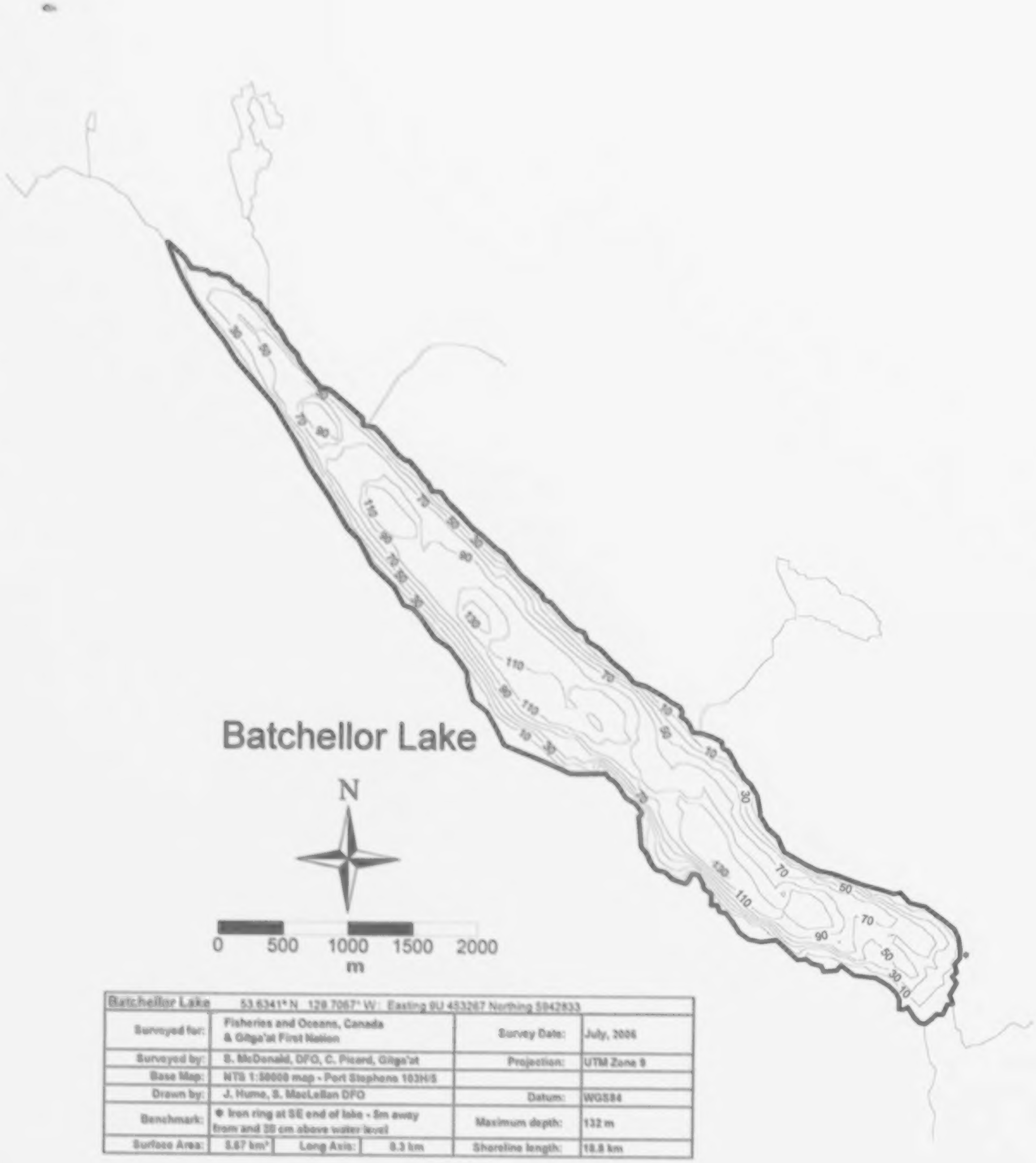
Fig. 2t. Map of Whalen Lake showing the trawl sections and hydroacoustic transects.



Alastair Lake
N
0 m
500 m
1000 m
1500 m
2000 m
5
10
20
10
5
20
20
40
60
60
20

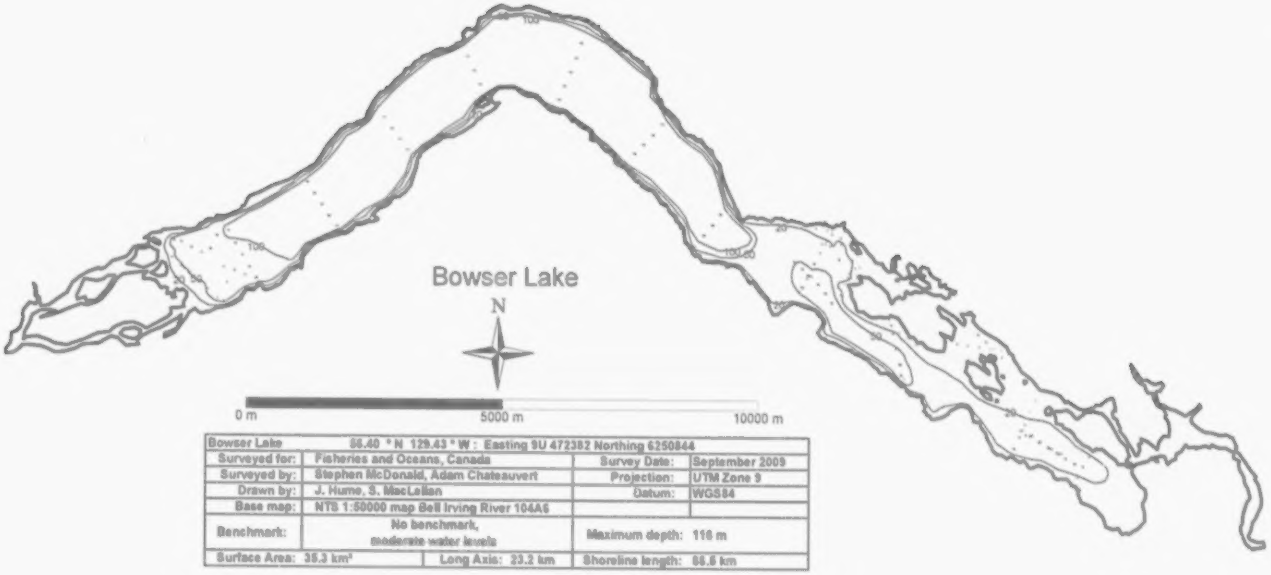
Alastair Lake	64.11 °N 129.18 °W ; Easting 9U 488190 Northing 6996197		
Surveyed for:	Fisheries and Oceans, Canada	Survey Date:	September 2009
Surveyed by:	Stephen McDonald, Adam Chateauvert	Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan	Datum:	WGS84
Base map:	NTS 1:50000 map Alastair Lake 106I3		
Benchmark:	No benchmark, moderate water levels	Maximum depth:	70 m
Surface Area: 6.86 km²	Long Axis: 8.4 km	Shoreline length:	20.8 km

Fig. 3a. Bathymetric chart of Alastair Lake.


Batchellor Lake
N
0
500
1000
1500
2000
m
10
30
50
70
90
110
130

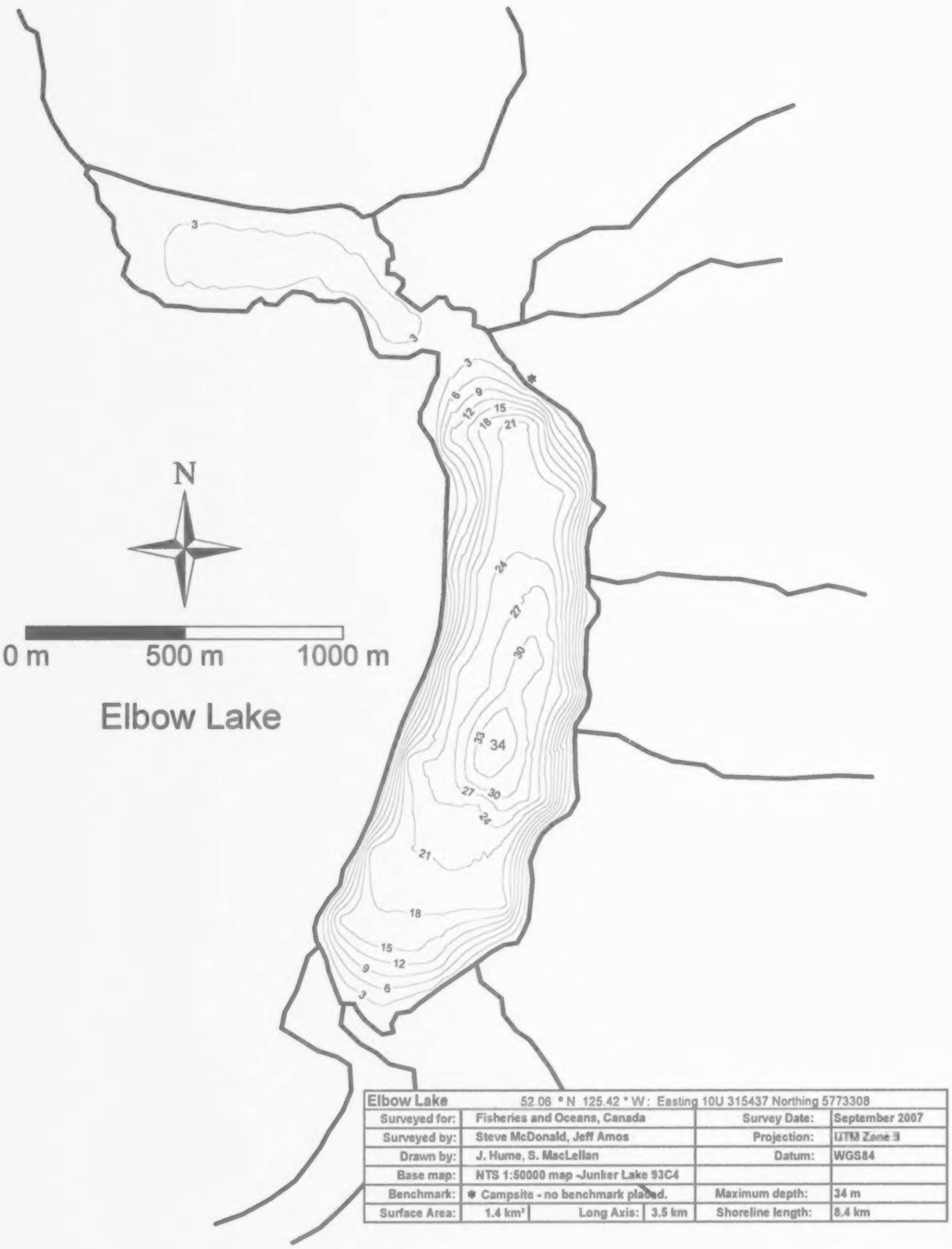
Batchellor Lake	53.6341° N 128.7067° W : Easting 9U 453267 Northing 5942833				
Surveyed for:	Fisheries and Oceans, Canada & Gitga'at First Nation			Survey Date:	July, 2006
Surveyed by:	S. McDonald, DFO, C. Picard, Gitga'at			Projection:	UTM Zone 9
Base Map:	NTS 1:50000 map - Port Stephens 103H/5				
Drawn by:	J. Hume, S. MacLellan DFO			Datum:	WGS84
Benchmark:	● Iron ring at SE end of lake - 5m away from and 50 cm above water level			Maximum depth:	132 m
Surface Area:	5.67 km²	Long Axis:	9.3 km	Shoreline length:	18.8 km

Fig. 3b. Bathymetric chart of Batchellor Lake



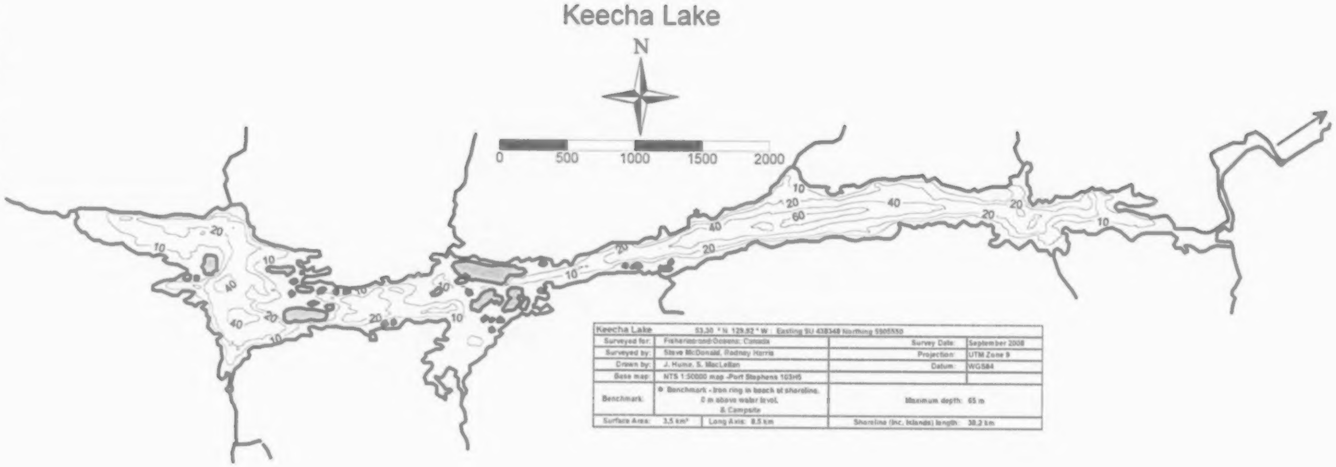
Bowser Lake	56.40 ° N 129.43 ° W : Easting 9U 472382 Northing 6250844		
Surveyed for:	Fisheries and Oceans, Canada	Survey Date:	September 2009
Surveyed by:	Stephen McDonald, Adam Chateauvert	Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan	Datum:	WGS84
Base map:	NTS 1:50000 map Bell Irving River 104A6		
Benchmark:	No benchmark, moderate water levels	Maximum depth:	116 m
Surface Area: 35.3 km²	Long Axis: 23.2 km	Shoreline length:	66.6 km

Fig. 3c. Bathymetric chart of Bowser Lake.


N
0 m
500 m
1000 m
Elbow Lake
3
3
3
6
9
12
15
18
21
24
27
30
33
34
27
30
24
21
18
15
12
9
6
3

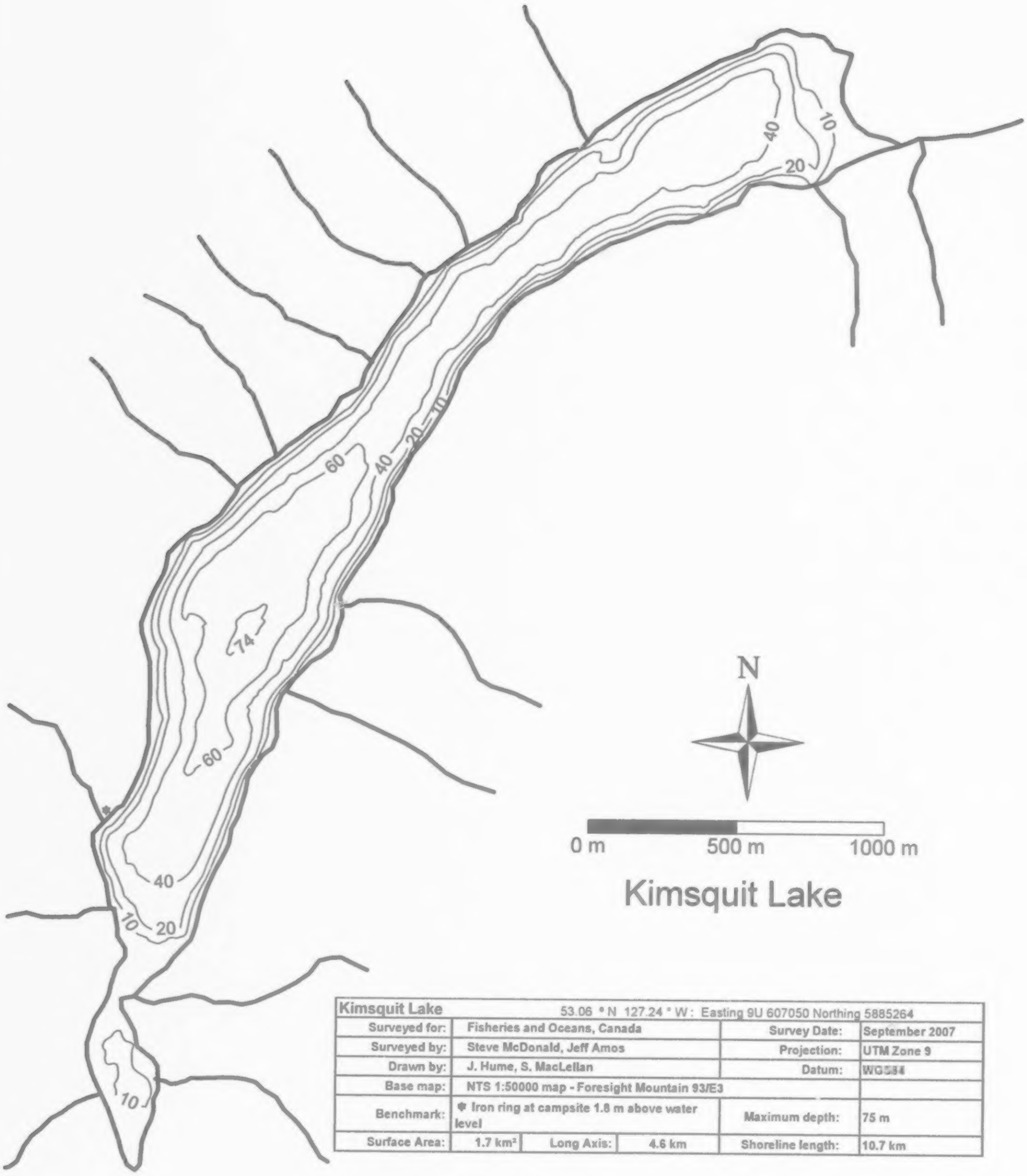
Elbow Lake	52.06 ° N 125.42 ° W: Easting 10U 315437 Northing 5773308				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September 2007
Surveyed by:	Steve McDonald, Jeff Amos			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map -Junker Lake 93C4				
Benchmark:	✱ Campsite - no benchmark placed.			Maximum depth:	34 m
Surface Area:	1.4 km²	Long Axis:	3.5 km	Shoreline length:	8.4 km

Fig. 3d. Bathymetric chart of Elbow Lake.



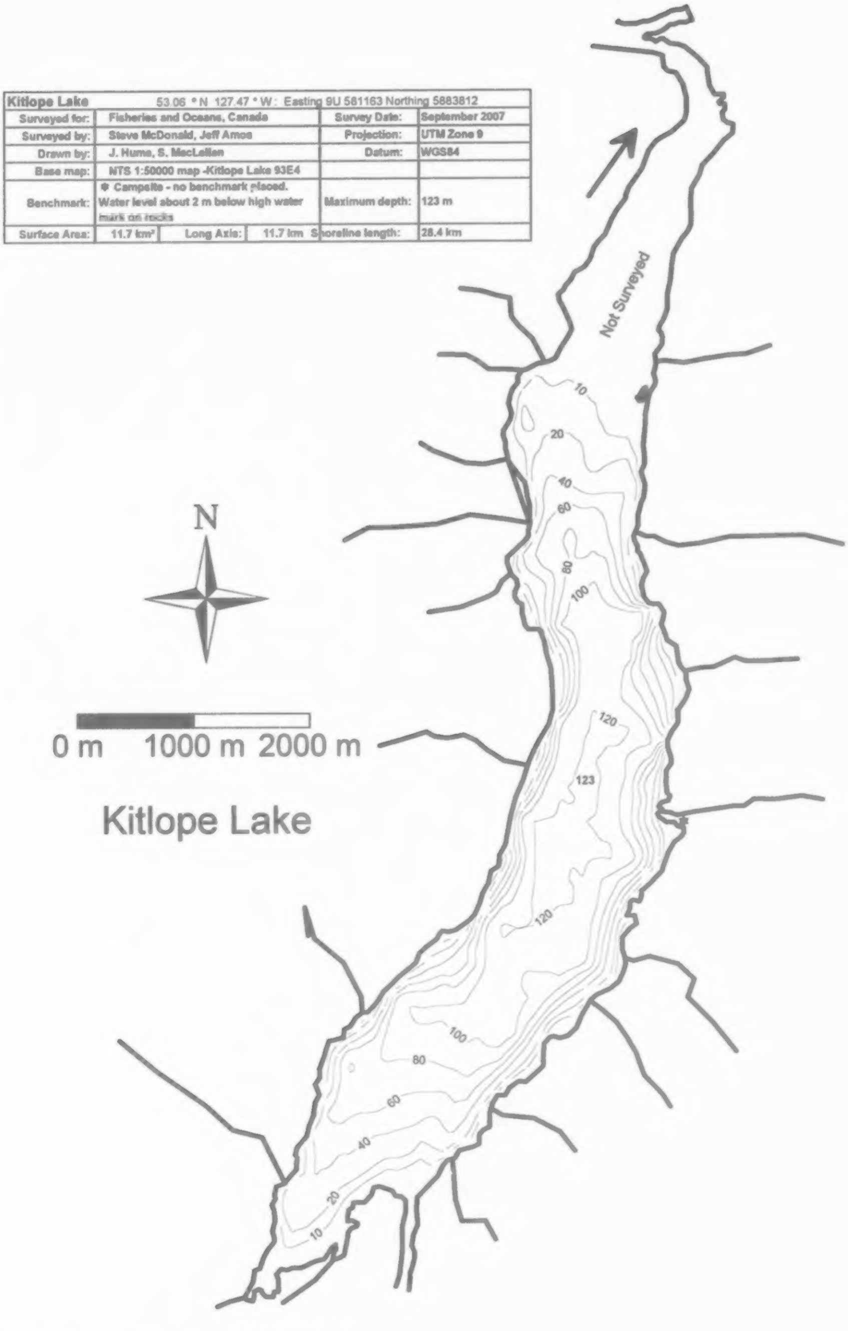
Keecha Lake	53.30 ° N 129.82 ° W : Easting 9U 438348 Northing 5905550		
Surveyed for:	Fisheries and Oceans Canada	Survey Date:	September 2008
Surveyed by:	Steve McDonald, Rodney Harris	Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan	Datum:	WGS84
Base map:	NTS 1:50000 map -Port Stephens 103H5		
Benchmark:	● Benchmark - iron ring in beach at shoreline. 0 m above water level. & Campsite	Maximum depth: 65 m	
Surface Area: 3.5 km²	Long Axis: 8.5 km	Shoreline (inc. islands) length: 38.2 km	

Fig. 3e. Bathymetric chart of Keecha Lake.


10
40
20
60
40
20
10
74
60
40
10
20
10
N
0 m
500 m
1000 m
Kimsquit Lake

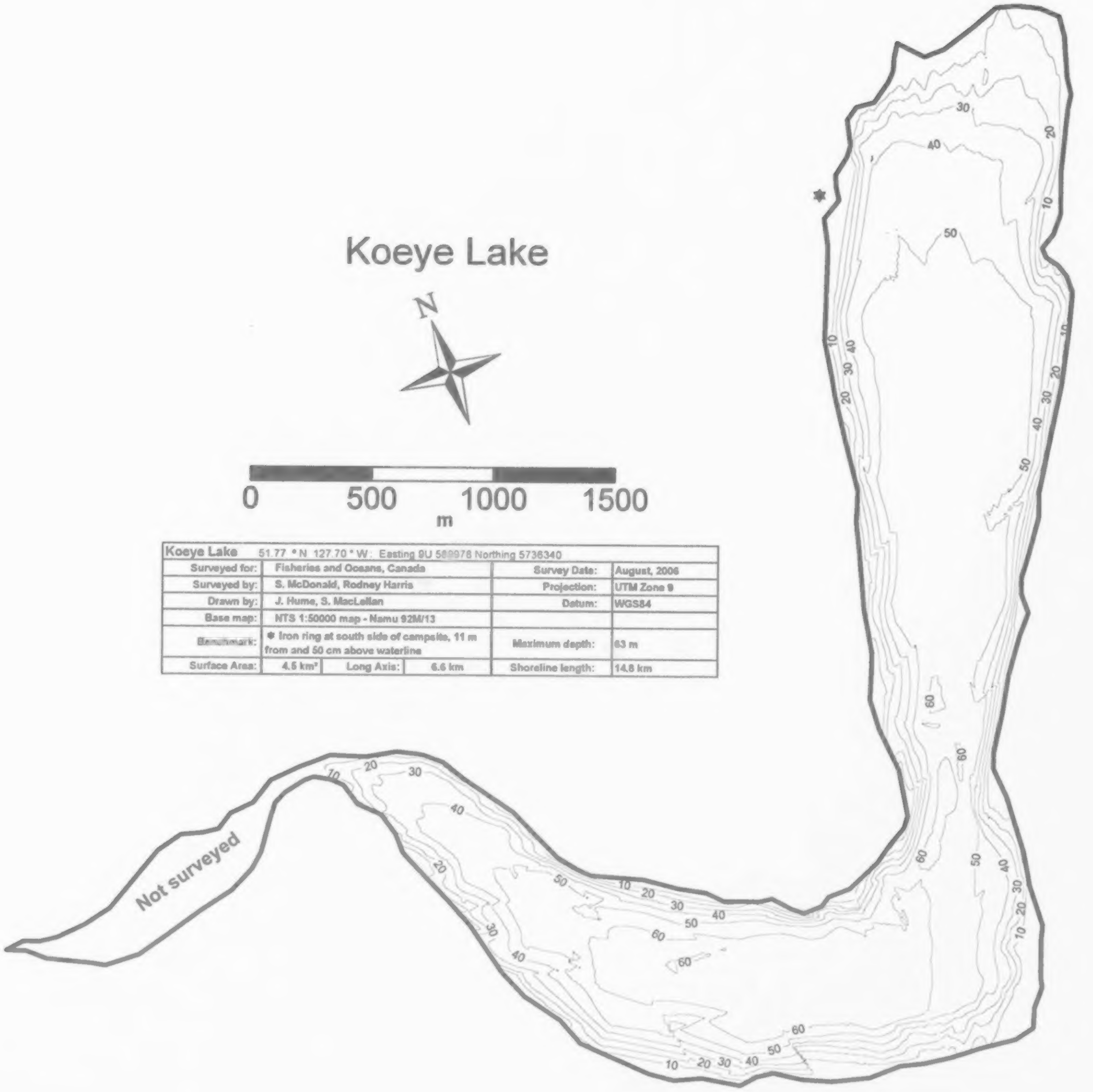
Kimsquit Lake	53.06 ° N 127.24 ° W : Easting 9U 607050 Northing 5885264				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September 2007
Surveyed by:	Steve McDonald, Jeff Amos			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map - Foresight Mountain 93/E3				
Benchmark:	✱ Iron ring at campsite 1.8 m above water level			Maximum depth:	75 m
Surface Area:	1.7 km²	Long Axis:	4.6 km	Shoreline length:	10.7 km

Fig. 3f. Bathymetric chart of Kimsquit Lake.


Not Surveyed
10
20
40
60
80
100
120
123
120
100
80
60
40
20
10
N
0 m
1000 m
2000 m
Kitlope Lake

Kitlope Lake	53.06 ° N 127.47 ° W : Easting 9U 581163 Northing 5883812				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September 2007
Surveyed by:	Steve McDonald, Jeff Amos			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map -Kitlope Lake 93E4				
Benchmark:	● Campsite - no benchmark placed. Water level about 2 m below high water mark on rocks			Maximum depth:	123 m
Surface Area:	11.7 km²	Long Axis:	11.7 km	Shoreline length:	28.4 km

Fig. 3g. Bathymetric chart of Kitlope Lake.


Koeye Lake
N
0
500
1000
1500
m
Not surveyed
10
20
30
40
50
60

Koeye Lake	51.77 ° N 127.70 ° W : Easting 9U 589978 Northing 5736340				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	August, 2006
Surveyed by:	S. McDonald, Rodney Harris			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map - Namu 92M/13				
Benchmark:	✱ Iron ring at south side of campsite, 11 m from and 50 cm above waterline			Maximum depth:	63 m
Surface Area:	4.5 km²	Long Axis:	6.6 km	Shoreline length:	14.8 km

Fig. 3h. Bathymetric chart of Koeye Lake.

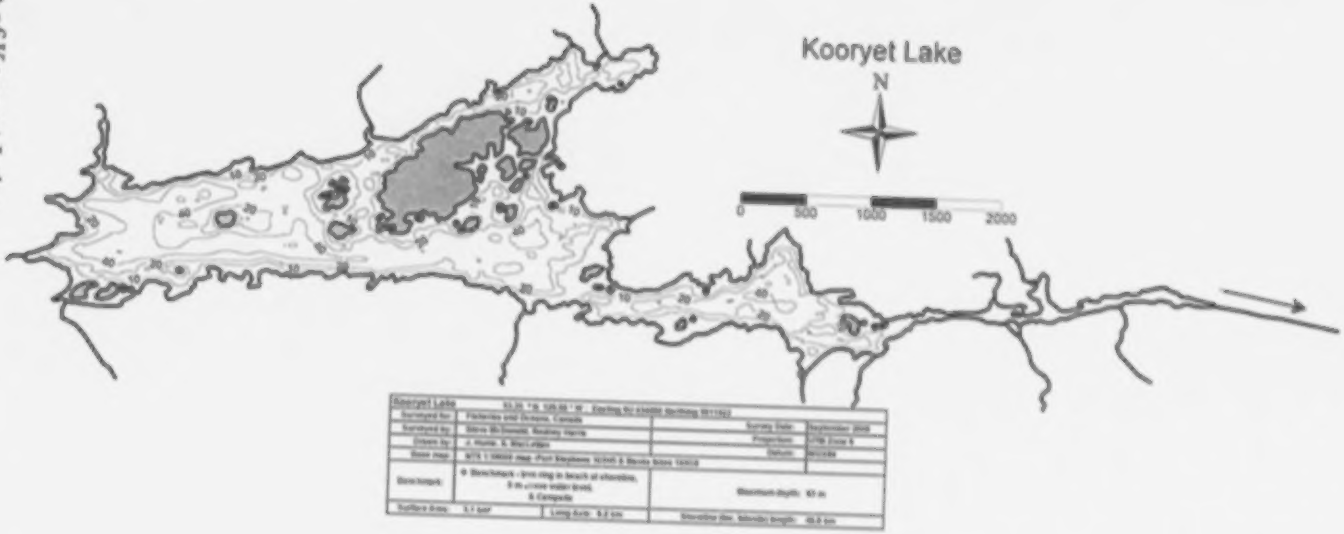
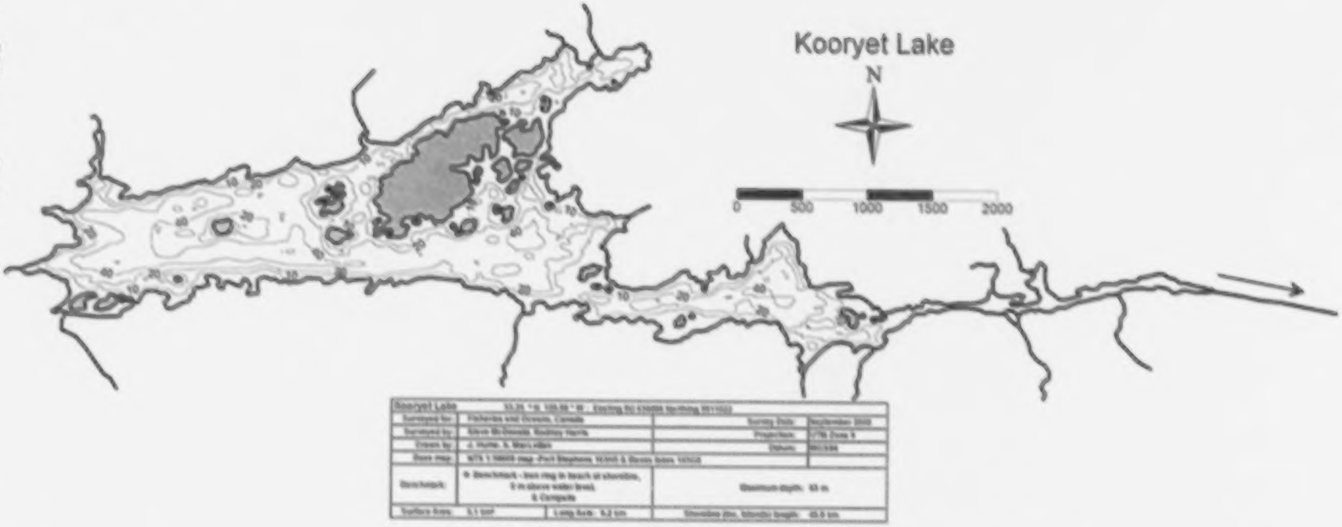
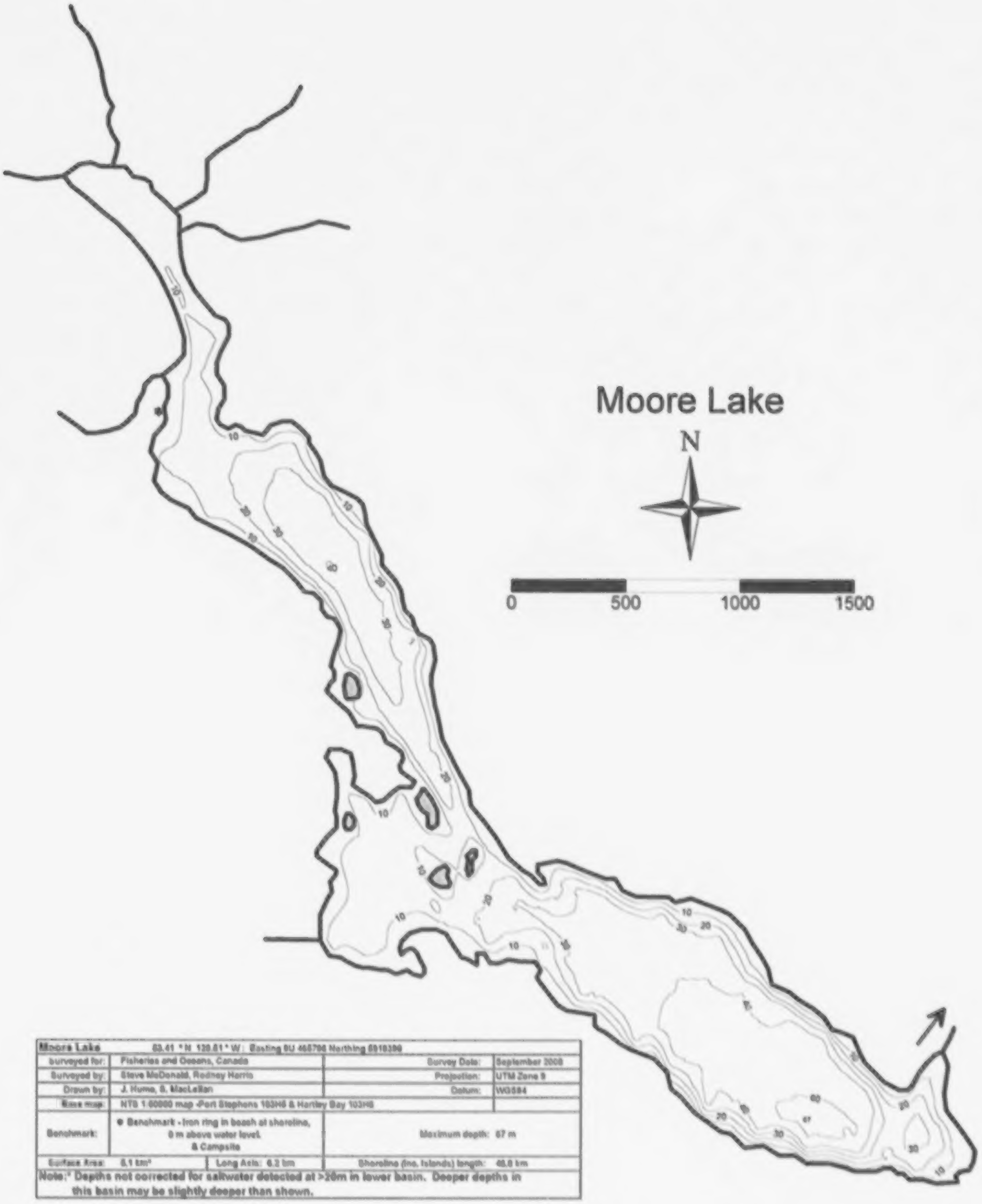

Kooryet Lake
N
0
500
1000
1500
2000
10
20
40

Fig. 3i. Bathymetric chart of Kooryet Lake.

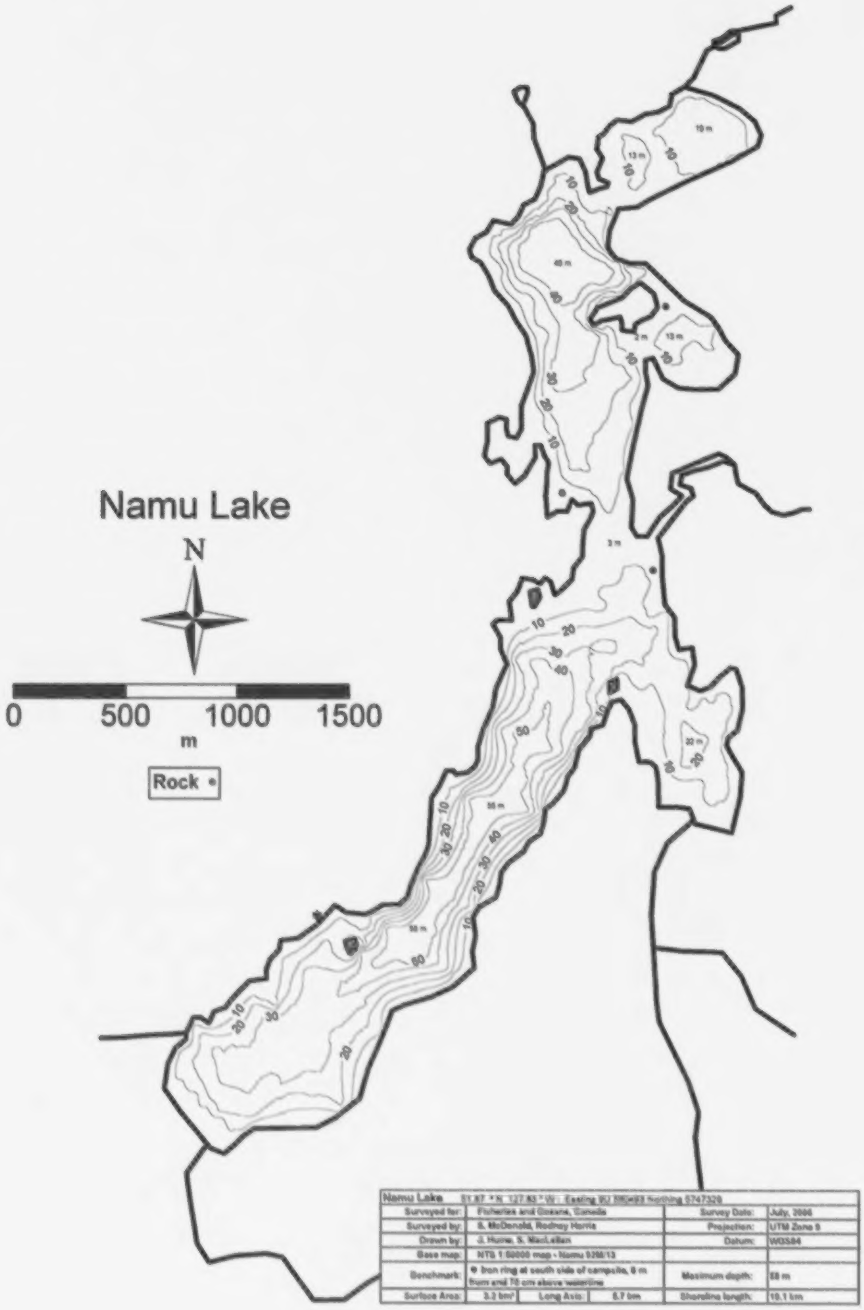
Fig. 3i. Bathymetric chart of Kooryet Lake.


Kooryet Lake
N
0
500
1000
1500
2000
10
20
Maximum depth: 53 m



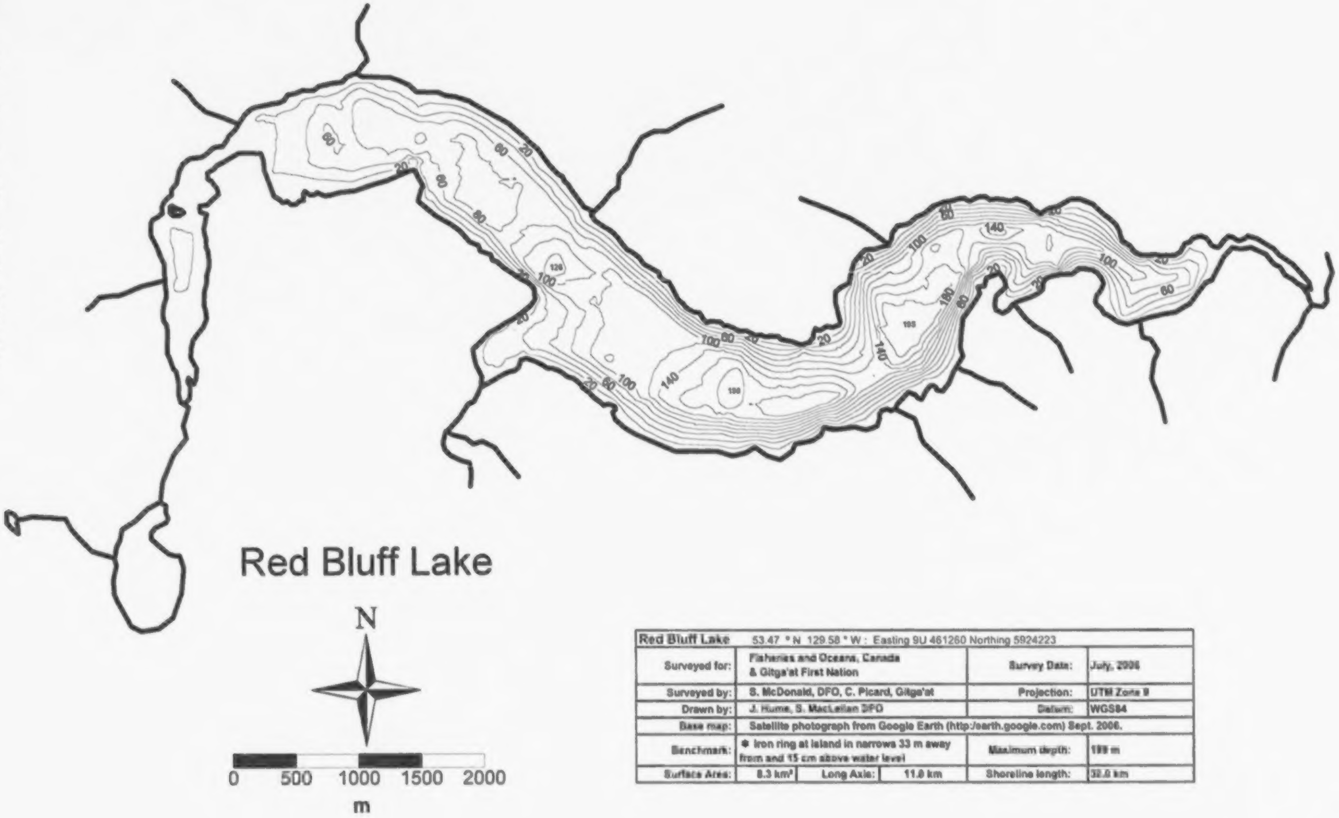
Moore Lake	53.41 °N 129.51 °W ; Easting 9U 468796 Northing 5918396		
Surveyed for:	Fisheries and Oceans, Canada	Survey Date:	September 2008
Surveyed by:	Steve McDonald, Rodney Harris	Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan	Datum:	WGS84
Base map:	NTS 1:50000 map -Port Stephens 103H6 & Hartley Bay 103H6		
Benchmark:	● Benchmark - Iron ring in beach at shoreline, 0 m above water level. & Campsite	Maximum depth: 67 m	
Surface Area: 5.1 km²	Long Axis: 6.2 km	Shoreline (inc. Islands) length: 46.8 km	
Note:* Depths not corrected for saltwater detected at >20m in lower basin. Deeper depths in this basin may be slightly deeper than shown.			

Fig. 3j. Bathymetric chart of Moore Lake.


Namu Lake
N
0
500
1000
1500
m
Rock •
10
20
30
40
50
60
10 m
13 m
40 m
3 m
3 m
13 m
22 m
58 m
58 m

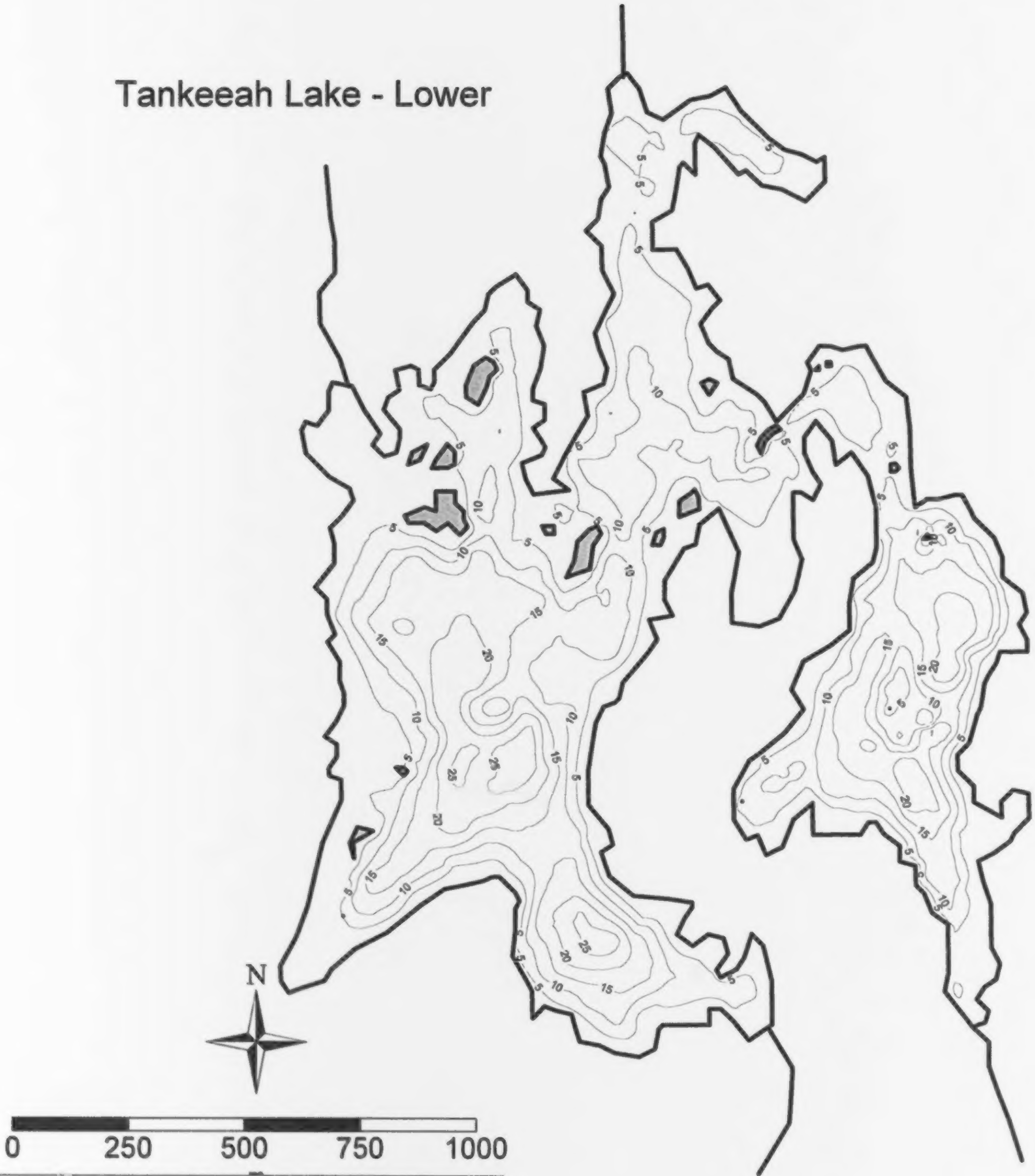
Namu Lake	51.87 °N 127.83 °W : Easting 9U 590493 Northing 5747329				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	July, 2006
Surveyed by:	S. McDonald, Rodney Harris			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map - Namu 92M/13				
Benchmark:	● Iron ring at south side of campsite, 8 m from and 70 cm above waterline			Maximum depth:	58 m
Surface Area:	3.2 km²	Long Axis:	5.7 km	Shoreline length:	19.1 km

Fig. 3k. Bathymetric chart of Namu Lake.


Red Bluff Lake
N
0
500
1000
1500
2000
m
20
60
80
100
120
140
180
190

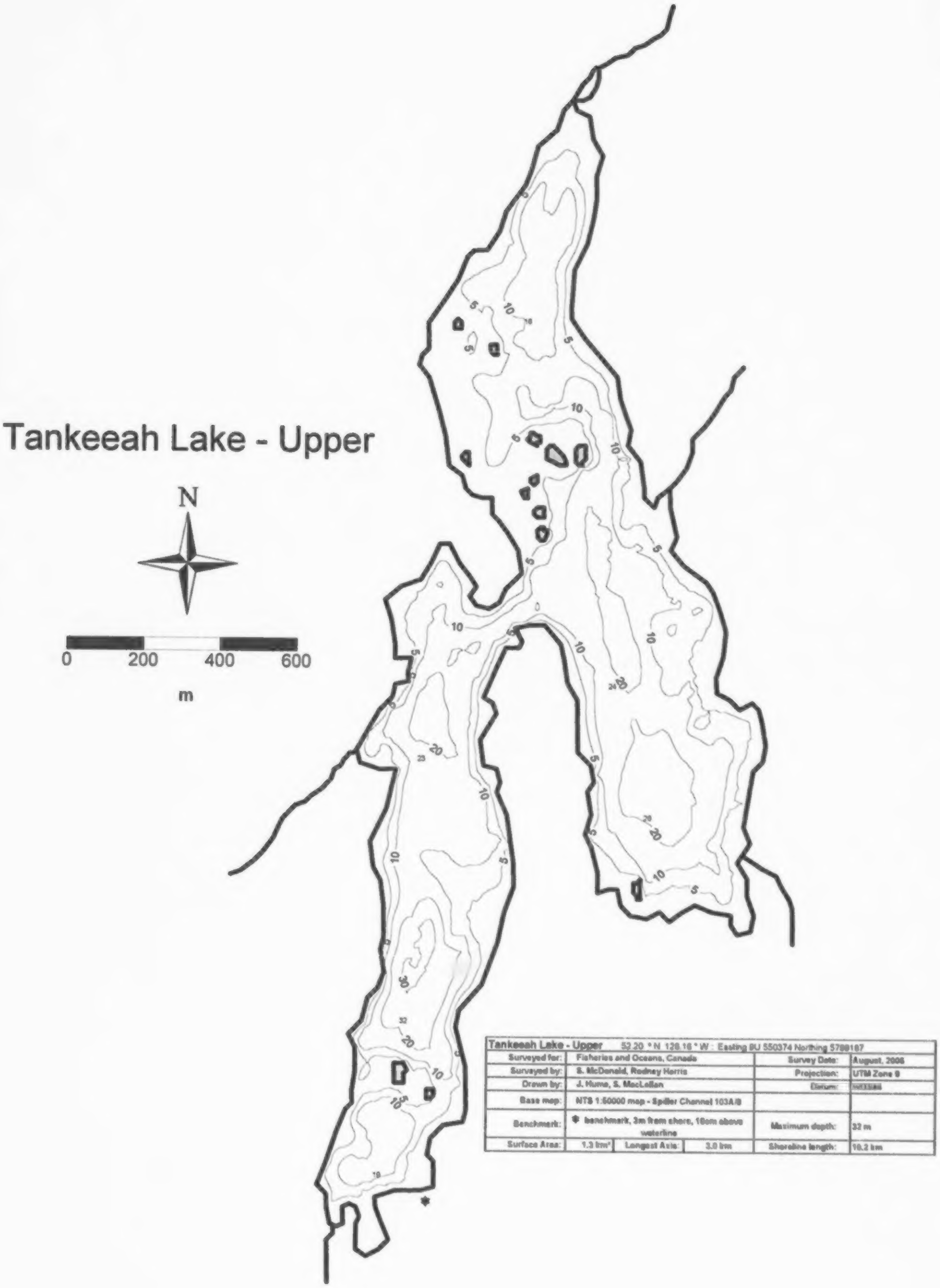
Red Bluff Lake	53.47 ° N 129.58 ° W : Easting 9U 461260 Northing 5924223			
Surveyed for:	Fisheries and Oceans, Canada & Gitga'at First Nation		Survey Date:	July, 2006
Surveyed by:	S. McDonald, DFO, C. Picard, Gitga'at		Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan DFO		Datum:	WGS84
Base map:	Satellite photograph from Google Earth (http:/earth.google.com) Sept. 2006.			
Benchmark:	✱ Iron ring at island in narrows 33 m away from and 15 cm above water level		Maximum depth:	199 m
Surface Area:	8.3 km²	Long Axis: 11.0 km	Shoreline length:	32.0 km

Fig. 31. Bathymetric chart of Red Bluff Lake.



Tankeeah Lake - Lower 52.32 ° N 128.27 ° W: Easting 9U 549756 Northing 5796223					
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	August, 2006
Surveyed by:	S. McDonald, Rodney Harris			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map - Spiller Channel 103A/8				
Benchmark:	no benchmark, lake level was high			Maximum depth:	28 m
Surface Area:	1.6 km²	Longest Axis:	2.1 km	Shoreline length:	14.75 km

Fig. 3m. Bathymetric chart of Tankeeah Lake (lower)



Tankeeah Lake - Upper	52.20 ° N 128.16 ° W : Easting 9U 550374 Northing 5799187				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	August, 2006
Surveyed by:	S. McDonald, Rodney Harris			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan			Datum:	[illegible]
Base map:	NTS 1:50000 map - Spiller Channel 103A/8				
Benchmark:	✱ benchmark, 3m from shore, 10cm above waterline			Maximum depth:	32 m
Surface Area:	1.3 km²	Longest Axis:	3.0 km	Shoreline length:	10.2 km

Fig. 3n. Bathymetric chart of Tankeeah Lake (upper).

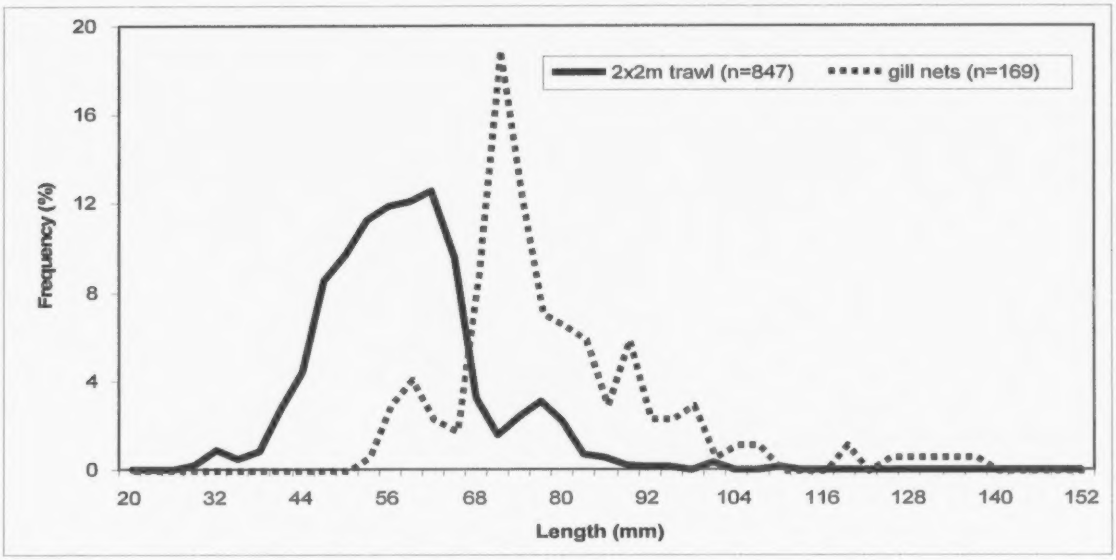


Fig 4a. Length frequency of all *O. nerka* caught during September surveys (17 lakes) using the small trawl and Swedish gill nets. Eight larger kokanee (>180 mm) caught by gillnets are not displayed. Data was grouped into 3 mm length bins for plotting.

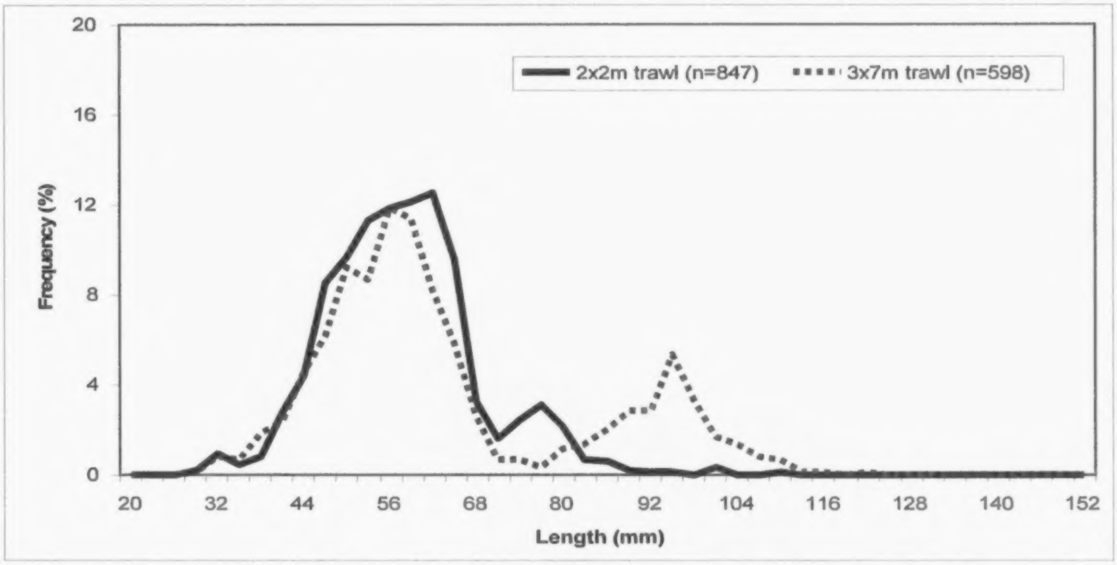


Fig 4b. Length frequency of all *O. nerka* caught during September surveys (17 lakes) using the large and small trawls. Data was grouped into 3 mm length bins for plotting.

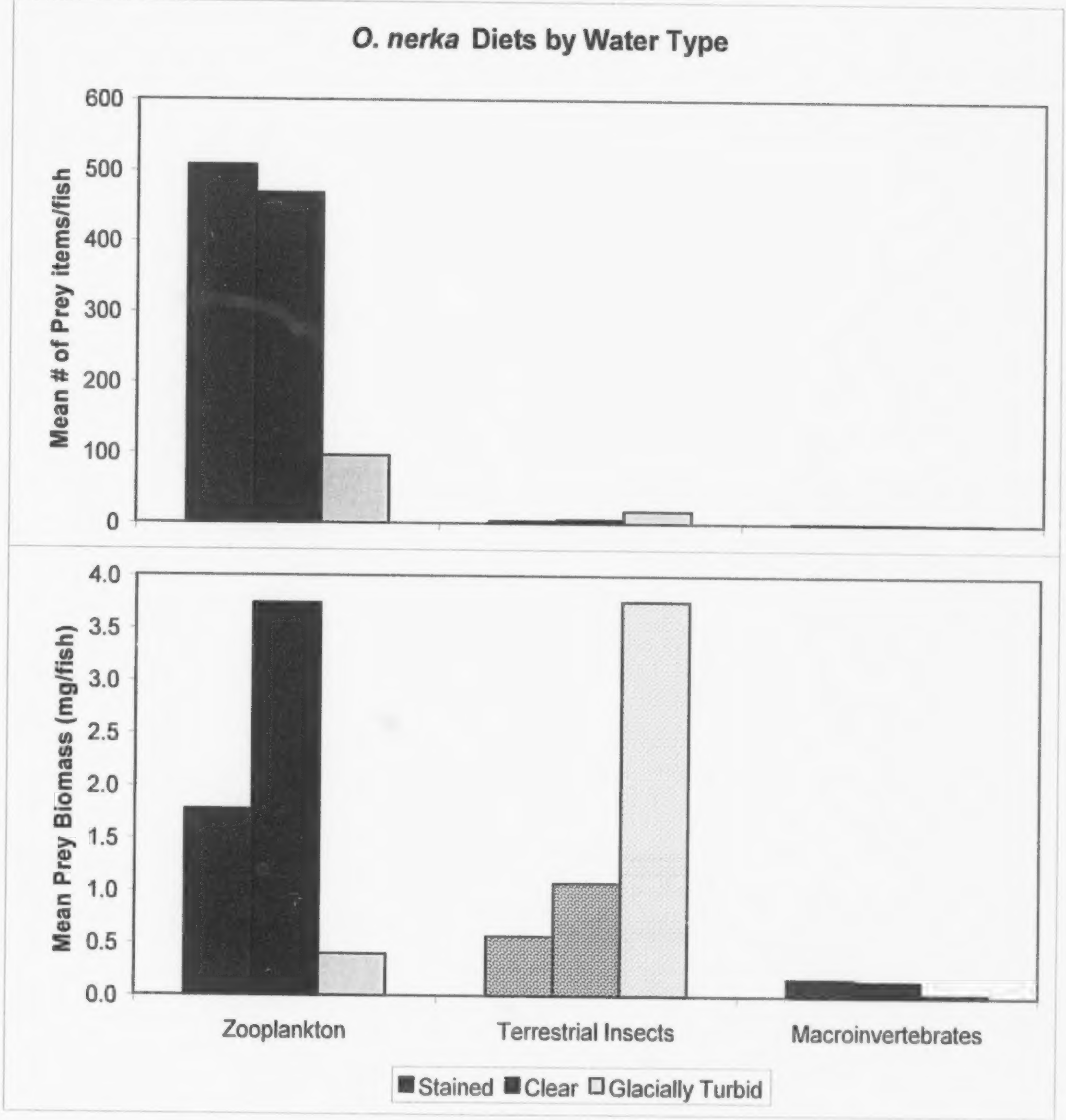


Fig 5. General components of the diet of age-0 and age-1 *O. nerka* averaged for each of the 3 lake types by abundance and by biomass. Diet data from this study and from Hume and MacLellan (2008) were pooled for this analysis. The biomass of terrestrial insects is not reliably measured. Macro-invertebrates includes *Chaoborus, Chironomid, and Ceratopogonid* larvae, *Neomysis,* worms, and amphipods.

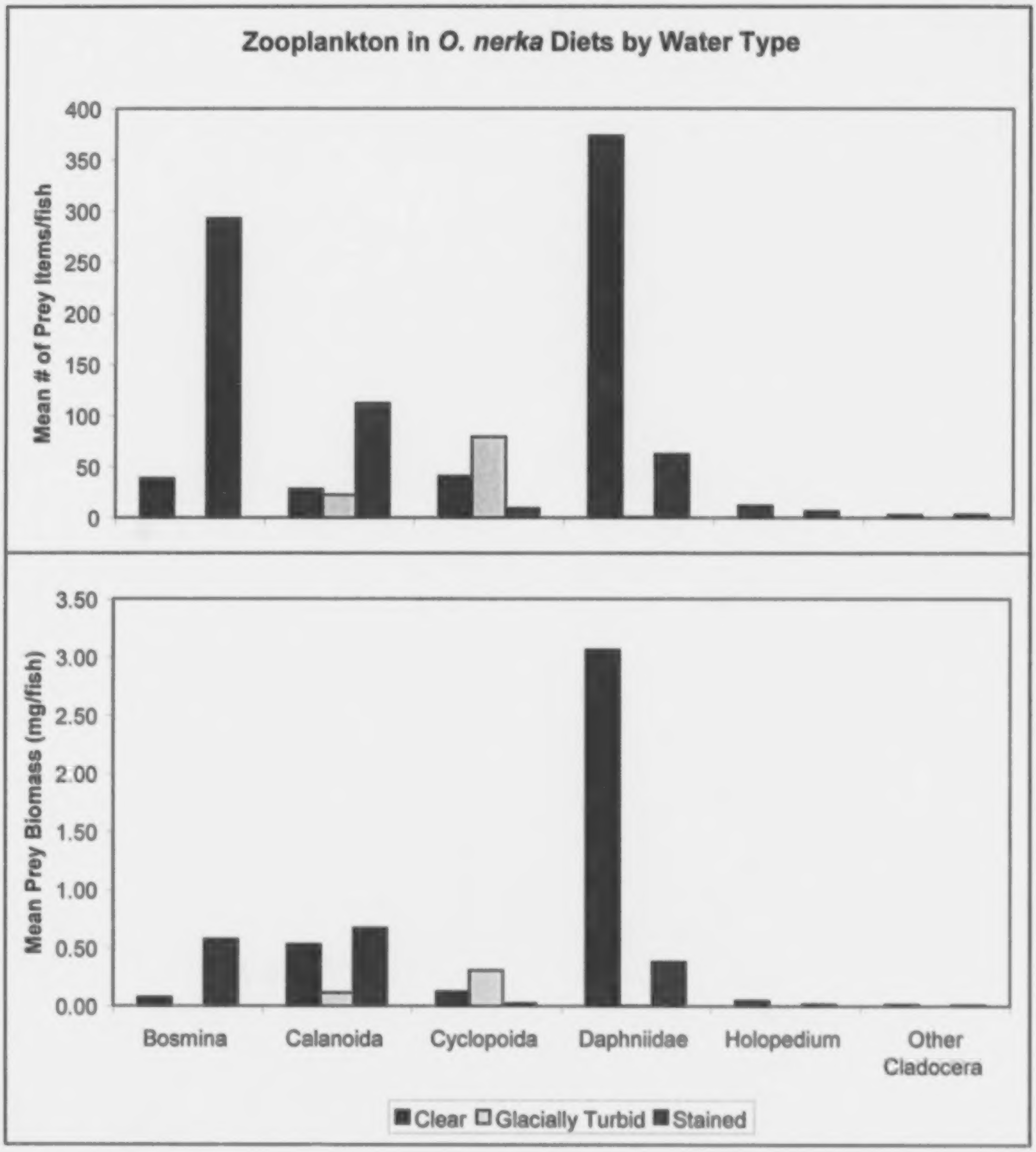


Fig 6. Zooplankton components of the diet of age-0 and age-1 *O. nerka* averaged for each of the three lake types by abundance and by biomass. Diet data from this study and from Hume and MacLellan (2008) were pooled for this analysis.

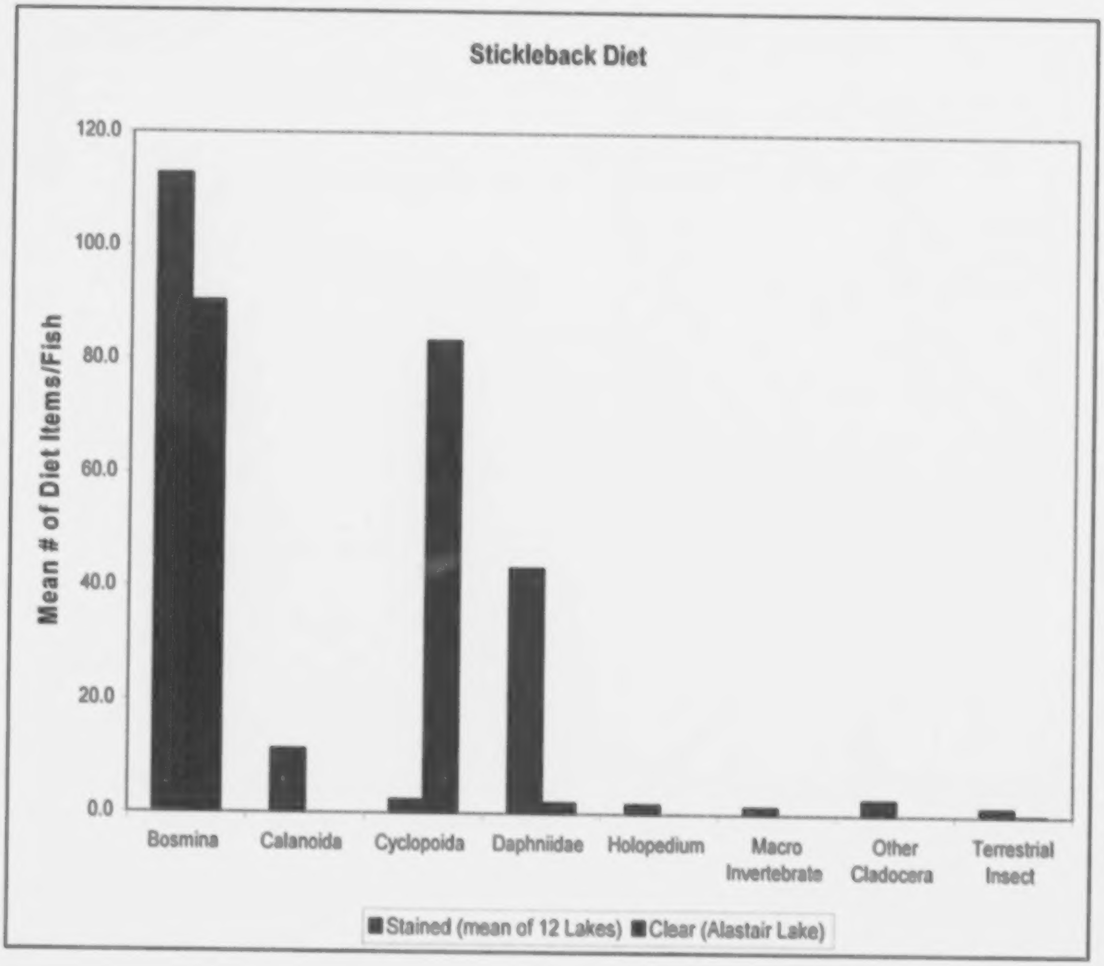


Fig. 7. Stickleback diet in stained and clear lakes. The values for stained lakes are an average of 12 lakes, whereas the clear lake values are from only one lake (Alastair Lake).

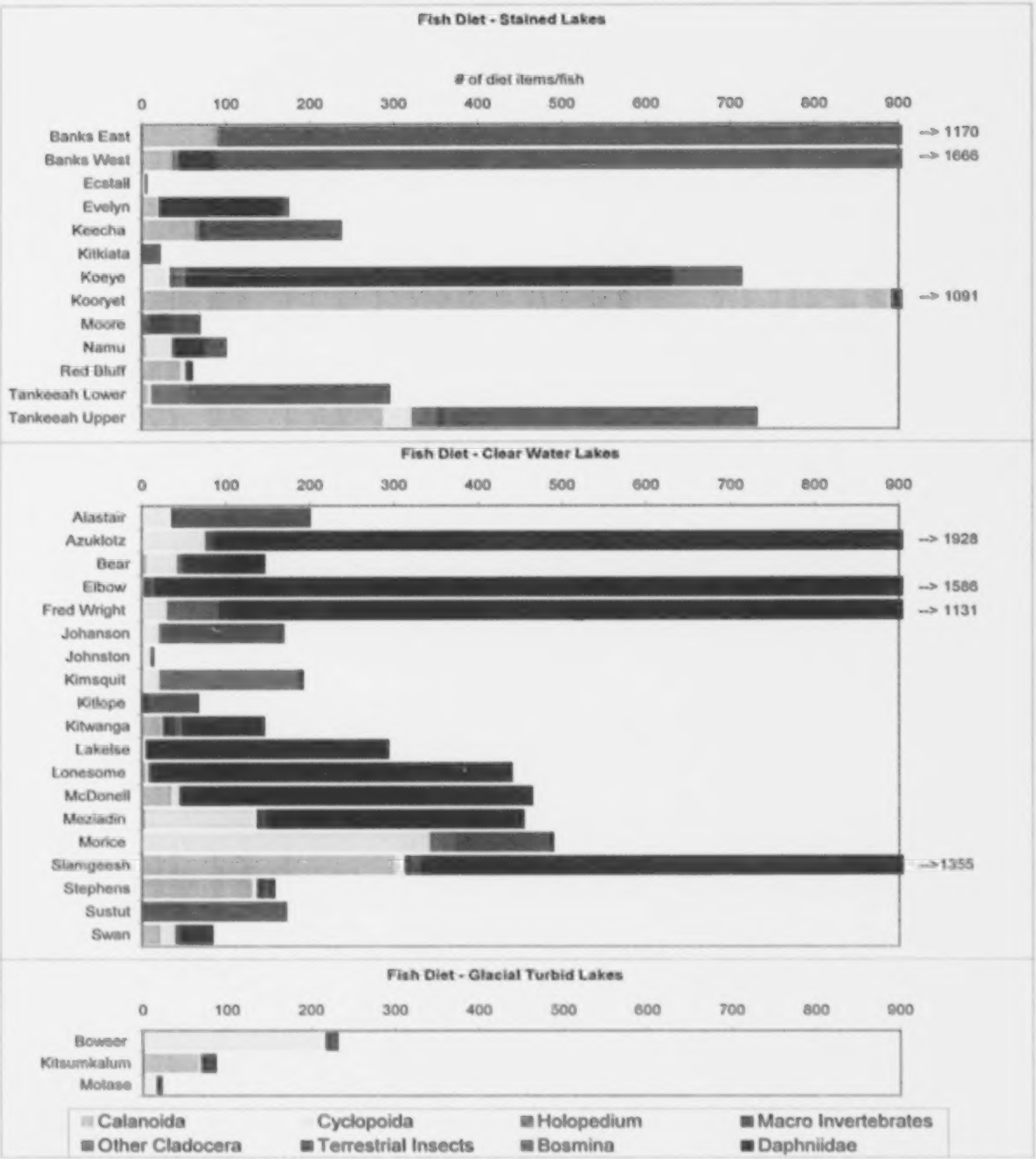


Fig. 8. Estimated abundance of prey items for age-0 O. nerka from lake surveys. Includes lakes covered by this report and Hume and MacLellan (2008).

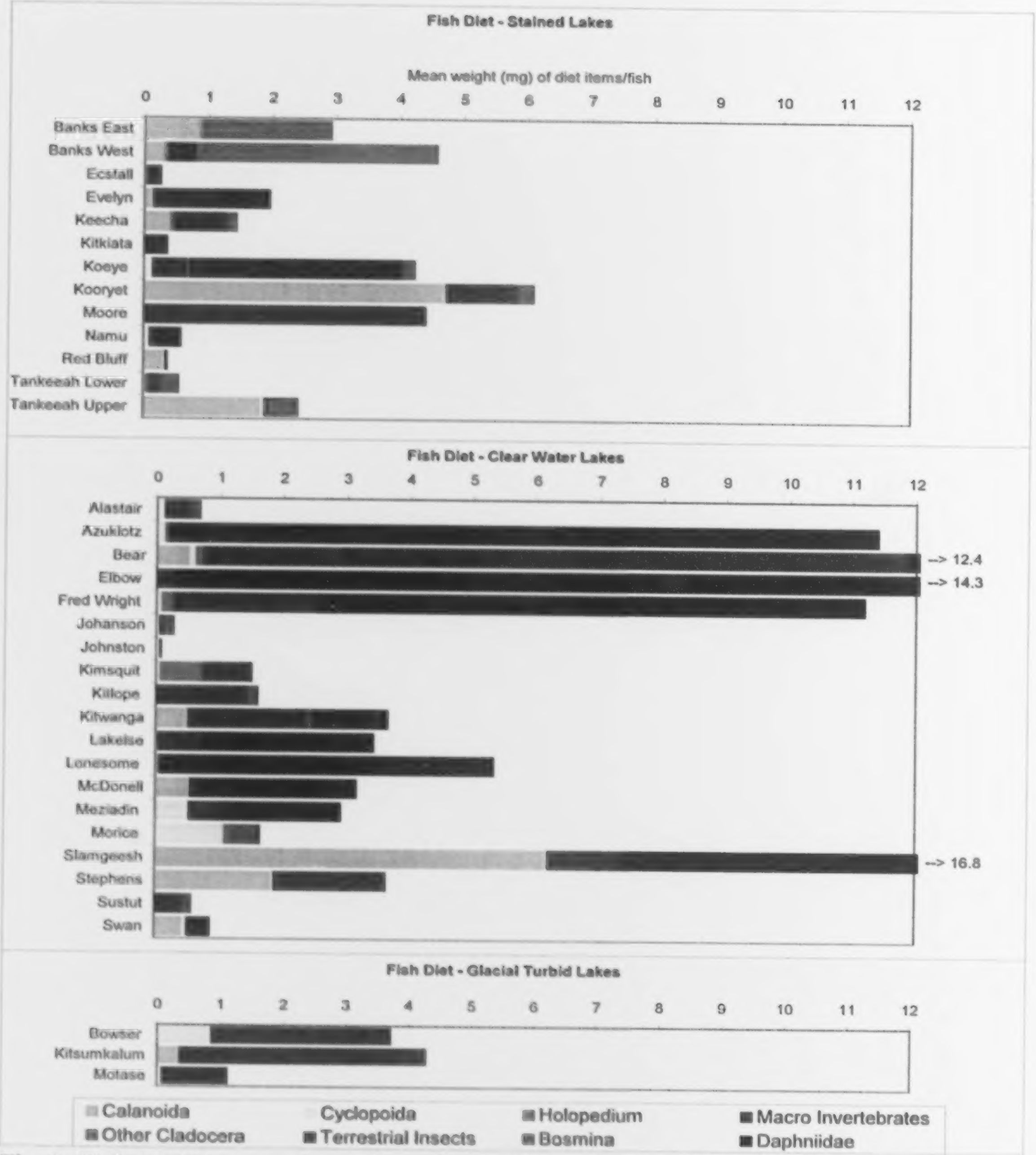


Fig. 9. Estimated biomass of prey items for age-0 *O. nerka* from lake surveys. Includes lakes covered by this report and Hume and MacLellan (2008).

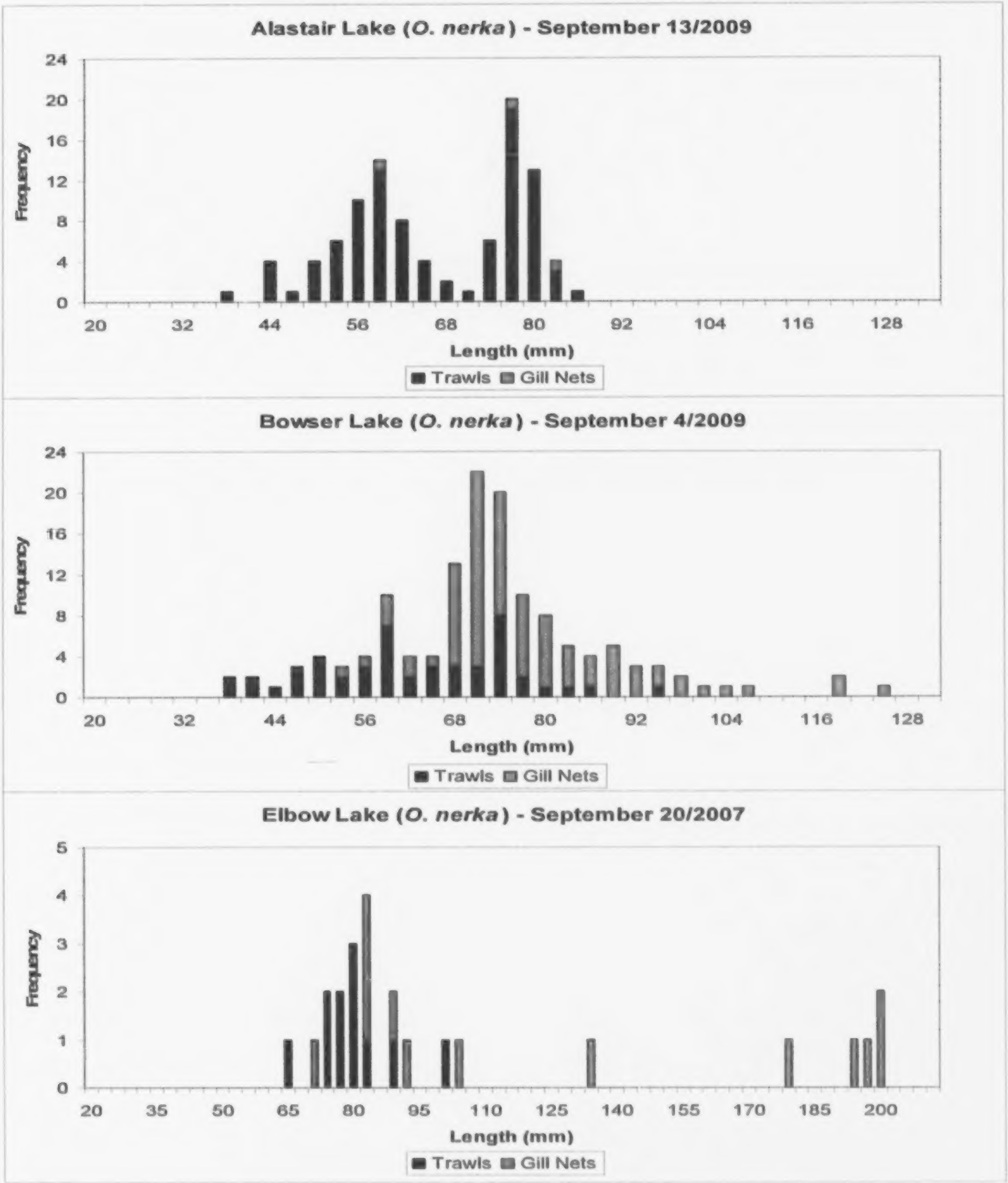
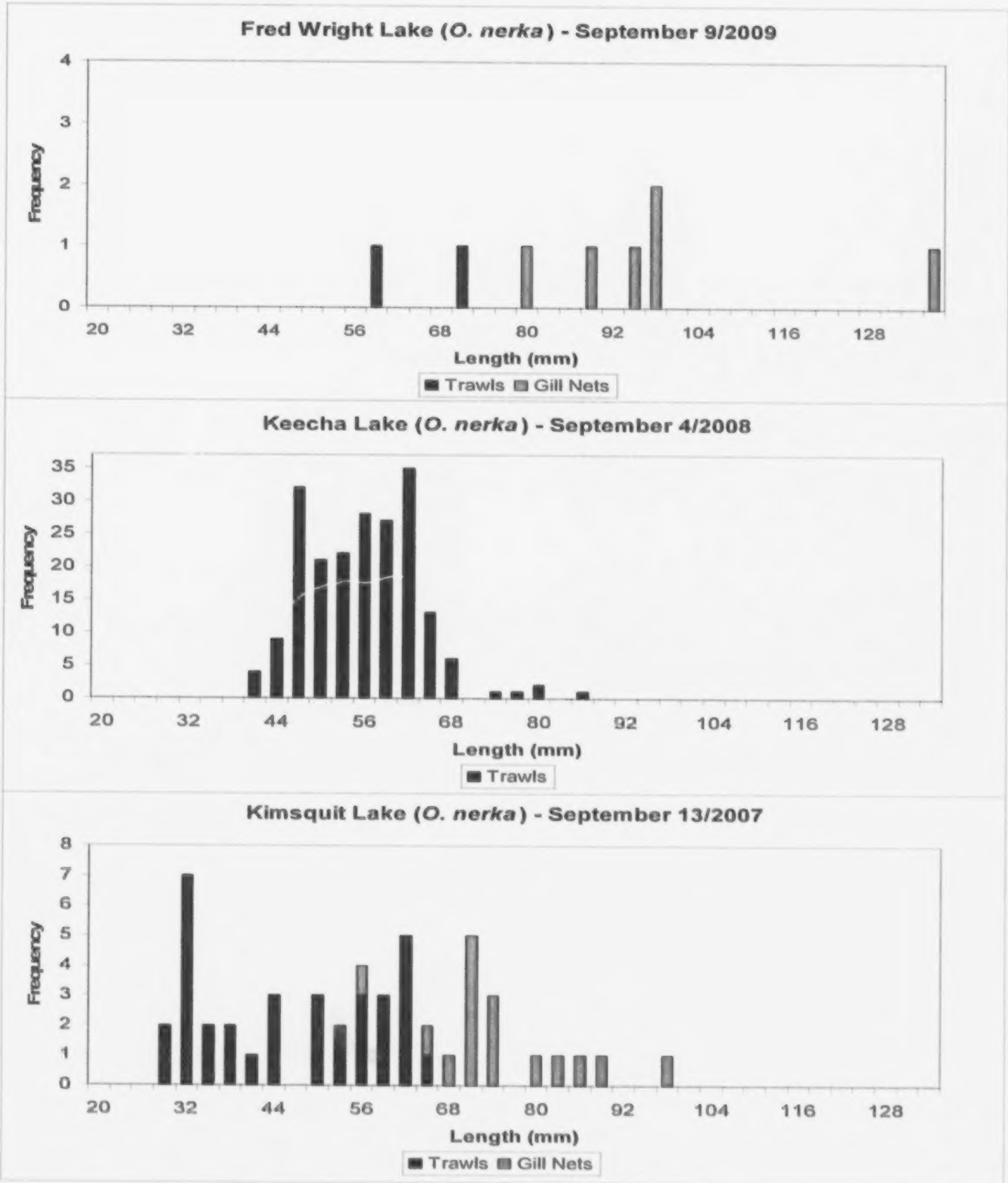


Fig. 10. Length frequency histograms of *O. nerka* from each survey



Fred Wright Lake (*O. nerka*) - September 9/2009

Keecha Lake (*O. nerka*) - September 4/2008

Kimsquit Lake (*O. nerka*) - September 13/2007

Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

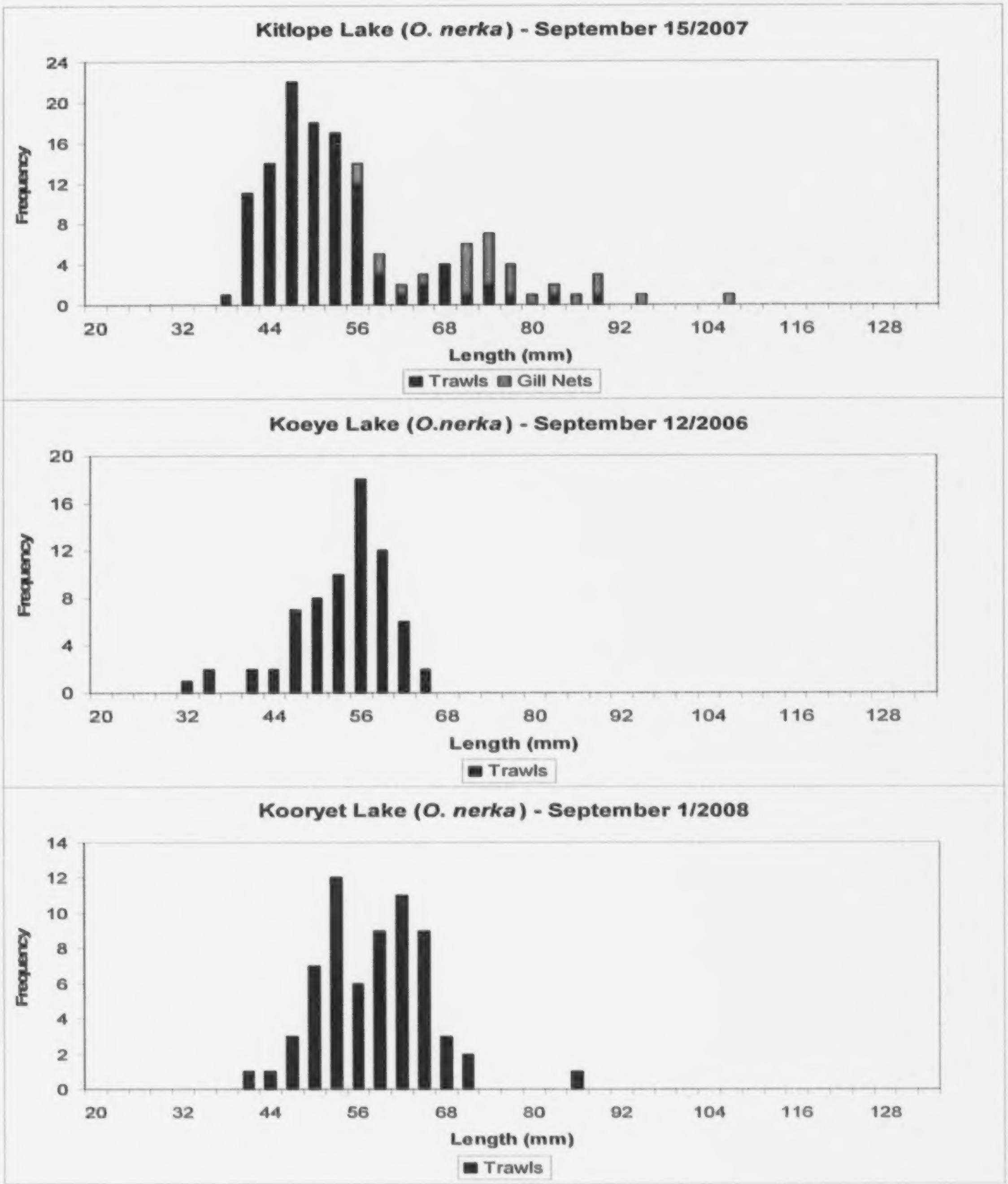


Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

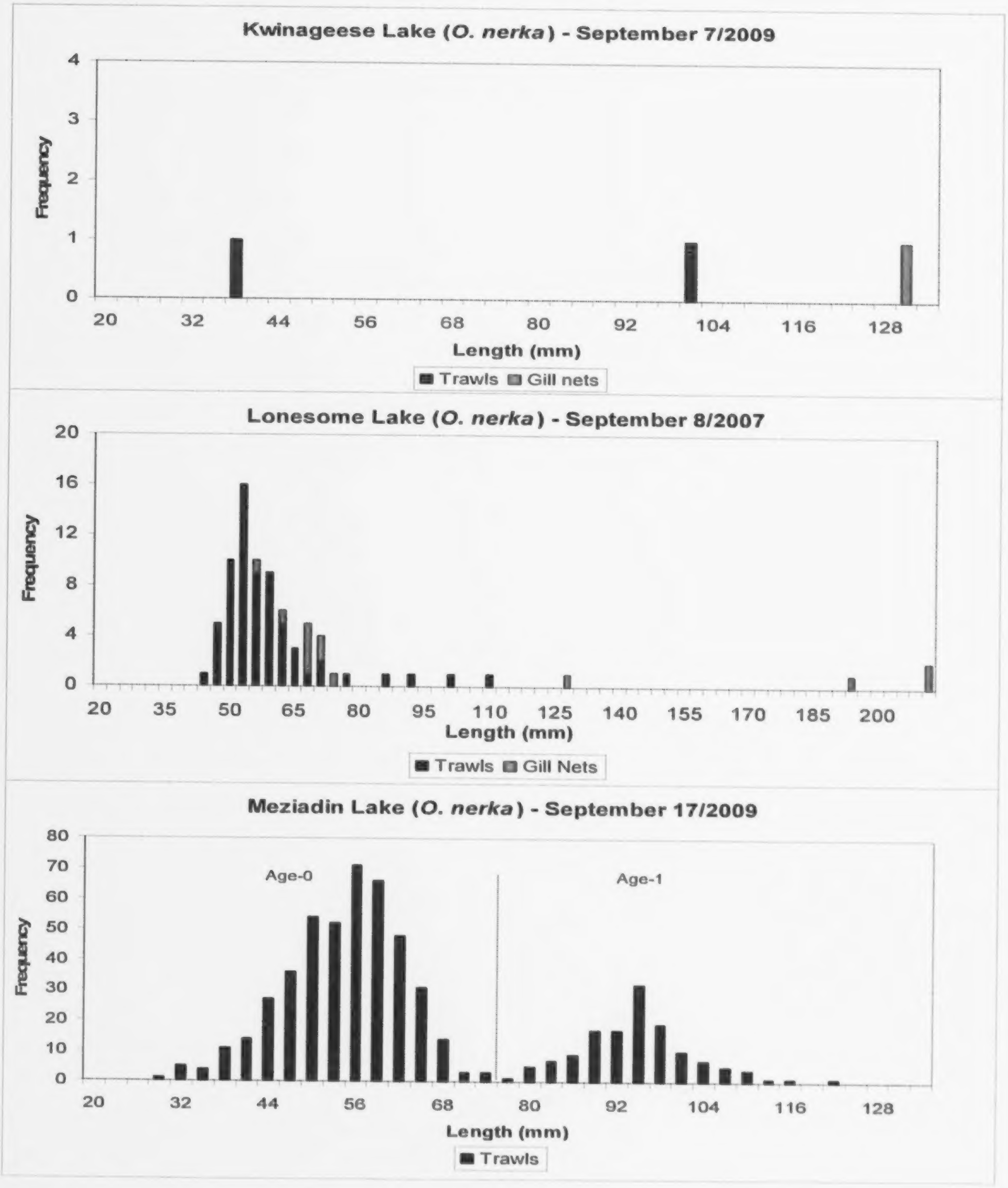


Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

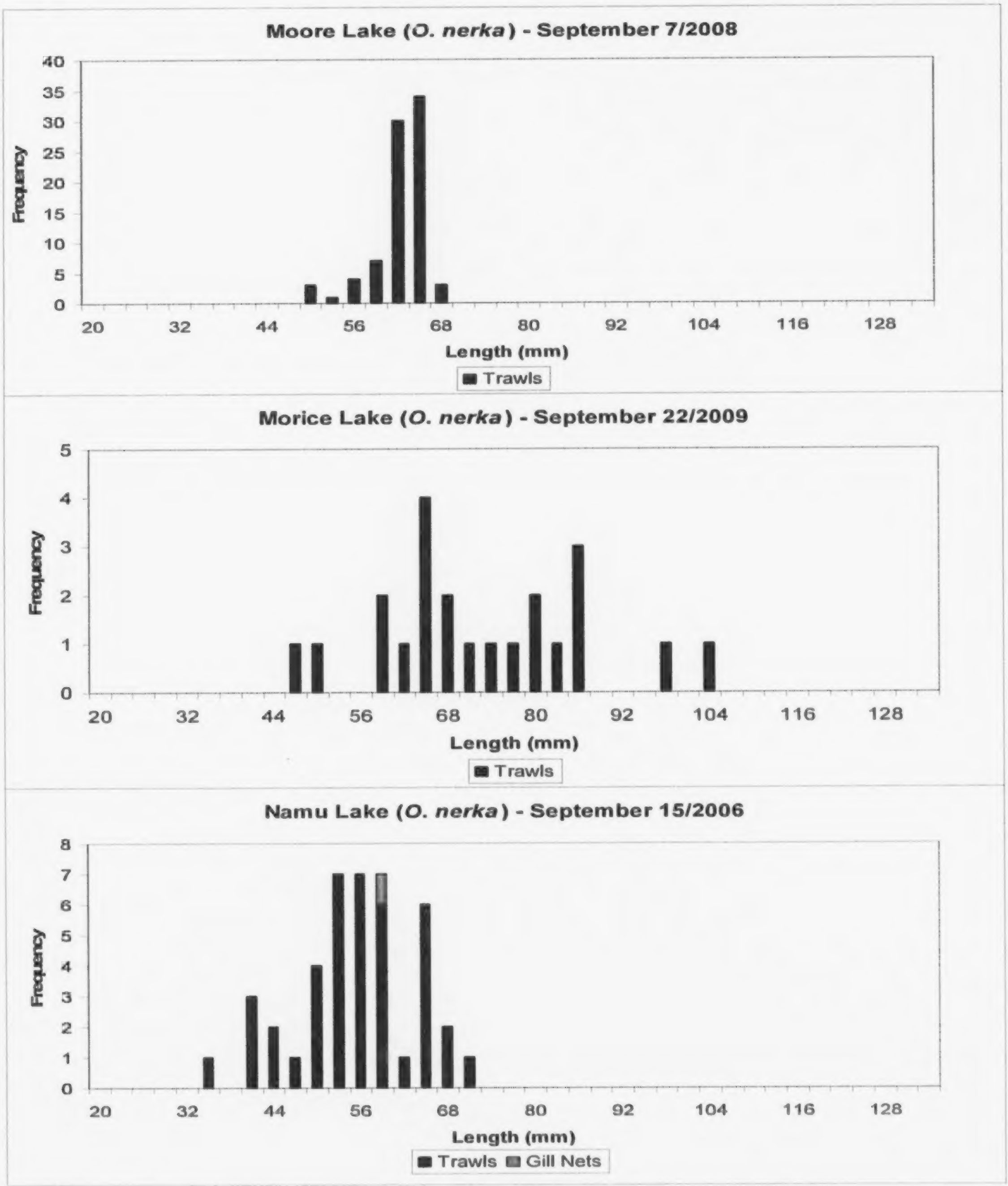


Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

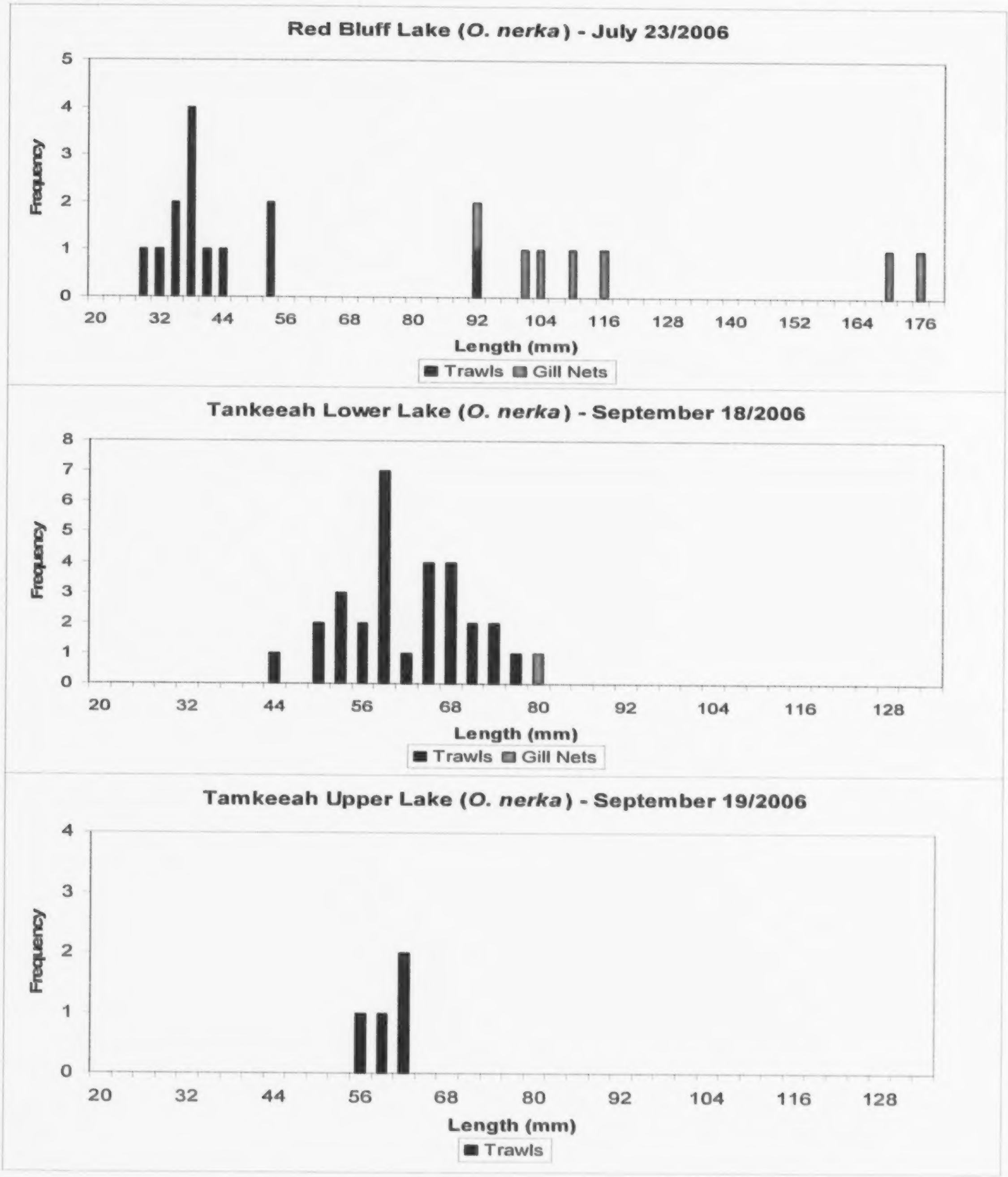


Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

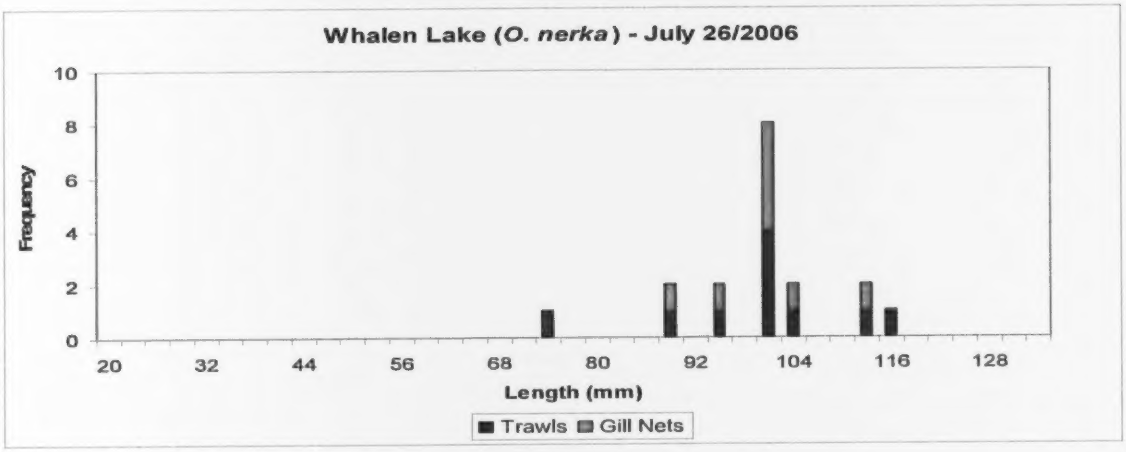


Fig. 10. Length frequency histograms of *O. nerka* from each survey (continued).

APPENDICES

APPENDIX 1. INDIVIDUAL LAKE REPORTS

Here we present general descriptions of each of the study lakes and the surveys, including highlights, difficulties encountered and how they were handled, and a description of the pelagic fish communities found. We also evaluate each lake's suitability for hydroacoustic assessment and recommend strategies for any future surveys on these lakes. For detailed survey results see the various tables, figures and appendices within this document.

Alastair Lake

Alastair Lake is located in the lower Skeena River drainage. The Gitnadoix River drains Alastair Lake and runs 20 km to the north, joining the Skeena River about 50 km from the Pacific Ocean. With an elevation of only 45 m above sea level, and a relatively short distance from salt water, its not surprising that harbour seals were observed in the lake during the survey in 2009. We surveyed this lake on September 13, 2009 with the Little Echo and the 2x2 m trawl. Initially we used an existing bathymetric chart (Simpson et al. 1981) but found it did not agree well with data from our hydroacoustic survey transects, so we developed a new chart from our survey transects plus data recorded during trawls (Fig. 3a).

Alastair was classified as a clear lake. We divided it into two sections; section one to the south is a deep basin with a maximum depth just under 80 m; to the north, section two is larger in surface area but much shallower with a maximum depth of 26 m (Fig 2a and 3a). The pelagic fish community of Alastair was dominated by threespine stickleback, with stickleback densities ranging from 4 900/ha in section 2 to 7 600/ha in section 1. *O. nerka* densities were relatively consistent throughout the lake at 544/ha. Stickleback lengths ranged from 14-71 mm with two or three size classes present. *O. nerka* were present in two age classes; Age-0 fish ranging from 37-64 mm in length and Age-1 fish from 63-86 mm length. *Daphnia*, juvenile sockeye's preferred food, made up <2% of the zooplankton community, most likely the result of cropping by the many planktivores in the lake, while *Bosmina* accounted for 72% of the zooplankton community (Appendix 6). *O. nerka* diet reflected these ratios with their diet consisting mainly of *Bosmina* (70-80%) and stomach fullness estimates ranging from 2% to 25% (Appendix 5). These results are consistent with those found in an October 1995 survey, where it was determined much of the potential sockeye rearing capacity of this lake was taken up by the stickleback population (Shortreed et al. 1998).

This lake is suitable for hydroacoustic assessment of pelagic fish populations. However, with large numbers of stickleback present, it is important to conduct extensive trawling to establish the relative proportions of stickleback and *O. nerka*, both in different areas of the lake, and at different depth layers. In our survey we found in section 1 (the deep section), that stickleback dominated the top 12 m of the water column, and *O. nerka* dominated below that level. In section 2 (the shallower section) the two species seemed to be more mixed throughout the water column. Also, because of the high densities of stickleback present in the upper depth strata, trawls targeting deeper strata are subject to significant contamination during deployment and retrieval of the net, and this contamination needs to be estimated in some manner. We estimated catch rates from trawls in the various depth layers and then estimated the time the net spent in those layers during deployment and retrieval to calculate contamination from shallower fish layers. To best accomplish this, detailed records on start and finish, time and position for each trawl, and of net depth over time must be recorded. A closing trawl system would be of great benefit to any survey on this lake, eliminating the need to estimate net contamination.

For future surveys of Alastair, transect 8 should be moved a little to the south, to take advantage of deeper water and avoid large woody debris which hampered navigation along its present course.

Batchellor Lake

We surveyed Batchellor Lake on July 20, 2006 with the Little Echo and the 2x2 m trawl. The purpose of this survey was to assess the lake's suitability for raising transplanted sockeye fry (Hanging Lakes Program). The lake is situated on the north coast of British Columbia, about 75 km northwest of Hartley Bay, and runs near and parallel to Grenville Channel. The lake drains via Batchellor Creek, which includes a barrier to anadromous fish, a short distance from Grenville Channel. We used survey and additional transects, along with additional soundings to construct a bathymetric chart for the lake (Fig. 3b). Batchelor Lake, like most of our coastal lakes, was classified as stained.

No *O. nerka* were detected in the lake. Our trawls caught no fish in the pelagic zone of Batchellor Lake but other gear caught a number of Dolly Varden and cutthroat trout (Tables 3 and 4). *Chaoborus* was found to be present, with highest densities toward the south end of the lake. Therefore acoustic data collection and processing was done using *Chaoborus* methods outlined in MacLellan and Hume (2010).

Batchellor Lake's morphology lends itself well to hydroacoustic assessments. However, future surveys will need to prepare for and deal with interference from *Chaoborus* larva when estimating fish abundance.

Bowser Lake

Bowser Lake is located about 60 km north of Stewart, B.C. and is in the interior of northern British Columbia, within the Nass River drainage. Although the Kitimat-Cassiar Highway passes close by, there was no road access, so we flew in by float plane and used the Little Echo with its 2x2 m trawl on September 4, 2009. Bowser is glacially turbid with turbidity values ranging from 18 to 60 NTU (Table 1), making this lake second only to Motase Lake as the most turbid lake we have worked on. Initially we used an existing bathymetric chart (FIDQ), but found it matched poorly with the transect soundings. Therefore we generated a chart based on the transect and trawl soundings along with some extra soundings taken just for this purpose (Fig. 3c).

With such high turbidity levels it's not surprising to see fish (*O. nerka*) behaving differently from what we see in relatively clear lakes. We found the *O. nerka* of Bowser Lake were behaving similar to those in Motase Lake (Hume and MacLellan 2008). These fish were extremely surface oriented, to such an extent as to make downward looking acoustics virtually useless. Hydroacoustics detected only a handful of fish throughout the entire survey, yet surface trawls produced 49 *O. nerka* of various ages (Table 3). Age-0 *O. nerka* averaged 52 mm in length and age-1 *O. nerka* averaged 70 mm. The surface trawls also indicate higher densities of *O. nerka* near shore, usually where water depth was less than 20 m. Since most of the *O. nerka* population was in the top 4 m of the water column, we used densities derived from the surface trawls to estimate *O. nerka* abundance. Densities were calculated for near shore and off shore areas of the lake and extrapolated for the whole lake to produce an abundance estimate of 131 000 *O. nerka*. Because of the limited sampling power of trawls relative to the whole lake, the reliability of this estimate is very low.

The diet of Bowser fish is similar to those of other glacial turbid lakes we have worked on, with a heavy reliance on terrestrial insects (Fig. 9). Although the estimation of insect biomass is uncertain relative to zooplankton biomass, the data clearly indicate that insects play a much more important role in juvenile sockeye diet in these glacially turbid lakes than in clear lakes. Perhaps this reliance on insects is what attracts these normally pelagic fish into more littoral habitat near shore. *O. nerka* diet and consequently growth and productivity appears to be associated more with the terrestrial environment and consequently production models based on the lake habitat such as the PR model are not appropriate.

Bowser Lake is not a good candidate for traditional (down looking) hydroacoustic assessment techniques. Fish behavior puts most of the population in the top 4 m of the lake, an area of the lake unseen by the transducer. A trawl survey is an option, but would require a great deal of effort to produce reliable results. Side looking acoustics is another option and should be investigated, but it is not without its own set of challenges, related to techniques, interpretation and calibration.

Elbow Lake

Elbow Lake is in the Bella Coola region of central British Columbia, about 86 km southeast of the town of Bella Coola and is within the boundaries of Tweedsmuir Provincial Park. This lake is the furthest lake up the Atnarko River Valley, and although glacially influenced, was rated clear because its range of turbidity readings fell below 5 NTU (Table 1).

We surveyed this lake on September 19, 2007 using the Little Echo and the 2x2 trawl. Using transect and additional soundings we created a bathymetric chart for the lake. The lake is relatively small, only 3.5 km long with a surface area of 1.4 km^2 (Fig. 2d). We excluded the shallow lower part of the lake (1 km long, max. depth 6 m) from the survey as it was unlikely to hold significant numbers of *O. nerka*. Exploratory transects detected no fish in that section of the lake and few fish were detected above 10 m in the deeper southern basin.

A surface trawl caught only a few small sculpins, which were unlikely large enough to be detected by the sounder at our data processing threshold. Other trawls caught 11 juvenile *O. nerka* and one juvenile coho. Gill nets caught a few northern pikeminnow and a mixture of *O. nerka* age classes, including some adult kokanee. We were not able to determine ratios of sockeye and kokanee within the juvenile *O. nerka* population. *Daphnia* were present in good numbers in this lake and as expected they were the most important item in the diet of Elbow Lake *O. nerka* (Fig. 8 and 9).

With the shallow section of this lake eliminated from consideration, Elbow Lake is easily surveyed using hydroacoustics and should produce reliable results. The only difficulty here is identifying juvenile sockeye from juvenile kokanee in the trawl and gill net samples.

Fred Wright Lake

Fred Wright Lake lies within the Nass River watershed in the interior of northern British Columbia about 78 km east of Stewart, B.C. It is drained by the Kwinageese River which runs north for 25 km until it joins the Nass River. Fred Wright is classified as clear, and we surveyed it on September 9, 2009 using the Little Echo and the 2x2 m trawl. We used a bathymetric chart produced by the Fish and Wildlife Branch in 1973 (FIDQ).

Trawls caught only two juvenile *O. nerka* and two sculpin. Gill nets were also low, catching only six *O. nerka* (4 age-1, 2 age-0) (Table 3). The only other fish caught was a large bull trout. Hydroacoustics detected only scattered targets throughout the lake, indicating no major sockeye population residing in the lake. A layer of fish was found in the arms at the south end of the lake. However, this layer is shallow (0-8 m) and somewhat shore oriented, so it is unlikely to consist of many, if any, *O. nerka*. Any future surveys might look for this assemblage and target it with trawl and gill nets to confirm what species is present. *Daphnia* were the most important food item found in the few *O. nerka* we did capture.

With such low densities of fish detected and the correspondingly low trawl catches, our confidence in the tracked target estimate of 45 000 *O. nerka* (Appendix 3) is low, although the estimate is reasonable when compared to recent acoustic surveys and trends for this stock. Estimates of age-0 sockeye in Fred Wright in previous years (1978-2004) have ranged from 41 069 to 648 500 fish and smolt studies in the Kwinageese River indicate the majority of migrating sockeye are age-1 fish (Bussanich 2005, Hall et al. In Prep), suggesting a four year life cycle for Fred Wright Lake sockeye. The 2009 estimate is the second lowest on record, but is consistent with the last acoustic survey conducted on this cycle (41 069 sockeye in 2001) and is consistent with the overall decline of adult spawners in recent years (Hall et al. In Prep).

The lake lends itself well to hydroacoustic assessment, and should substantial numbers of juvenile sockeye be rearing in the lake in the future, an acoustic survey should provide reliable estimates of *O. nerka* abundance.

Keecha Lake

Keecha Lake is located on the north coast of British Columbia on Banks Island. The lake is 8.5 km long, with many islands, and drains a short distance east into Principe Channel. We surveyed Keecha on September 4, 2008 with the Little Echo and the 2x2 m trawl. Keecha was classified as stained. We created a chart for this lake using survey transects, additional transects approximately half way between the survey transects, and additional soundings around larger shoal areas (Fig. 3e).

Chaoborus larva are present in Keecha Lake. They were captured by SCOR nets and they are evident on some echograms. The distribution of *Chaoborus* around the lake appears to be quite patchy, with some transects showing areas of moderate to high densities, and other transects showing no *Chaoborus* at all (at fish analysis thresholds). Where detected by the acoustics, *Chaoborus* was usually found in the top 15 m of the water column. Because *Chaoborus* is present in acoustically detectable densities, integration analysis was not used. Instead, Chaoborus–TT methods were used to estimate fish abundance (MacLellan and Hume 2010).

Both stickleback and *O. nerka* inhabited the pelagic zone of Keecha Lake. Trawls indicated both were vertically stratified with overlapping ranges. Threespine stickleback predominated in the shallower layers of the water column. Stickleback were rather large in this lake, as large and sometimes larger than the age-0 *O. nerka*. Of the 202 juvenile *O. nerka* caught, only five were age-1 fish, the remainder were age-0. Other species caught, besides stickleback, were Dolly Varden and sculpin (Tables 3 and 4). With *Daphnia* notably absent from the zooplankton community in Keecha Lake, *O. nerka* diet consisted mainly of Bosminidae and *Diaptomus*, along with some terrestrial insects.

Keecha is a multibasin lake with numerous islands and shoals, which makes night time navigation and trawling (in some areas of the lake) challenging. With both *Chaoborus* and abundant stickleback in the lake, hydroacoustic data collection and analysis need to be modified to use *Chaoborus* techniques (MacLellan and Hume 2010) and trawling needs to be expanded, to not only cover all basins, but several depth strata within each basin to get good estimates of *O. nerka*/stickleback ratios for the various depth strata. With these extra efforts, hydroacoustic surveys of this lake should produce reasonable estimates of *O. nerka* abundance.

Kimsquit Lake

Kimsquit Lake is located in the mountains northeast of the Kitlope River at an elevation of 358 m and drains east and then south for about 46 km to the top end of Dean Channel. While there are several ice fields in close proximity of Kimsquit Lake, the lake was apparently not affected by glacial melt waters (0.1 NTU) and was classified clear (Table 1). We surveyed this lake using the Little Echo and the 2x2m trawl on September 13, 2007. From our transect acoustics and additional soundings we produced a bathymetric chart of the lake (Fig. 3f).

The fish in Kimsquit, which were almost all *O. nerka*, were distributed fairly evenly over most of the lake, and at a relatively shallow depth of 4-10 m. Fish densities did not appear to extend to the surface and a surface trawl (0-2 m) caught no fish. Other trawls and gillnets caught a total of 50 *O. nerka* and one sculpin (Tables 3 and 4). *O. nerka* were present in three size classes and scale aging indicated that the two smaller size classes were both age-0 and the largest class was age-1. This distribution of sizes and ages suggests the presence of a kokanee population in the lake as well as anadromous juvenile sockeye. Diet information indicates *Holopedium* and insects are important in the diets of Kimsquit *O. nerka* (Appendix 5).

Over all, Kimsquit Lake is well suited to hydroacoustic surveys due to its deep waters and the predominance of *O. nerka* in the fish population. The only concerns are with respect to the shallow distribution of the fish which is nearing the limits of detection for downward looking transducers and estimating the proportion of sockeye verses kokanee within the *O. nerka* population.

Kitlope Lake

Kitlope Lake is located in the north coast region of British Columbia and is within the Kitlope Heritage Conservancy Protected Area. It is located only 10 km from salt water at the head of Gardner Canal, yet it is quite some distance from the Pacific Ocean and thus exhibits a mix of climate characteristics typical of the coast and the interior coastal mountains (Stockner et al. 1993). At only 13 m above sea level, seals have easy access to the lake and were observed during the survey. We surveyed Kitlope on September 15, 2007 using the Little Echo and 2x2 m trawl. We generated a bathymetric chart from the survey transect data, supplemented with some additional soundings (Fig. 3g).

We classified Kitlope as clear because turbidity was well below 5 NTU at the time of our survey. However, this lake has shown large variations in water clarity in the past, both spatially and seasonally, due to its fast flushing rate and dynamic surface circulation patterns and the way they distribute the glacially turbid water from the Tezwa River (Stockner et al. 1993). Stockner recorded Secchi depths as low as 1 m with a compensation depth of 3.7 m during their 3 year study of the lake. These values are often associated with turbidity readings over 5 NTU, which indicates that this lake would occasionally qualify for the glacially turbid category.

Trawls caught 100 age-0 *O. nerka* with a mean length of 50 mm and 10 age-1 *O. nerka* with a mean length 72 mm (Table 3). Simpson et al. (1981) found similar sized fall fry in 1978 with a mean length of 48 mm. Stockner et al. (1993) suggested that the juvenile sockeye in Kitlope Lake were found in the top 10 m of the water column. Our survey found much of the *O. nerka* population was in the top 2-3 m of the lake. Since our acoustics do not adequately sample this region of the water column we calculated density for the 0-2 m strata from our surface trawl catches. A comparison between hydroacoustic and trawl net derived density for the top most ensonified layer (2-4 m) was favorable, so we have some confidence in the surface strata density estimate derived from surface trawls. Other species present in our trawl catches were threespine stickleback and sculpin, but these species were a very minor portion of the pelagic community. *Eubosmina* and insects were important diet items for the *O. nerka* of Kitlope Lake.

Kitlope Lake is a relatively noisy environment (hydroacoustically) with a fair bit of interference from bubbles, currents and debris. This limitation, coupled with fish behavior and their preference for occupying the surface layers, makes this lake only marginally suitable for hydroacoustic surveys. Future surveys need to adequately assess the surface layers of Kitlope Lake. The acoustic interference present in the lake may make surface trawls the preferred method of assessing the surface layers rather than side looking acoustic technology. In any case, all acoustic data will likely contain a fair bit of noise which will have to be removed through editing.

Koeye Lake

Koeye Lake was classified as a stained lake and is situated on the central coast of British Columbia about 14 km southeast of Namu. It is 53 m above sea level and the outlet flows 10 km west into Fitz Hugh Sound. We surveyed Koeye on September 12, 2006 using the Little Echo and the 2x2 m trawl. A log jam at the outlet of the lake prevented us from including Little Koeye Lake in the survey. A bathymetric chart was generated from the survey and additional soundings of the lake (Fig. 3h).

Chaoborus larva were present on all transects of this lake and in relatively high densities on several transects. Because echoes from these larvae interfere with and overlap with fish echoes, we used a modified tracked target analysis (MacLellan and Hume 2010) to estimate fish abundance at about 484 000 *O. nerka* (Appendix 3).

The trawl caught 71 fish (Appendix 2); all but one were juvenile *O. nerka* averaging 53 mm in length, indicating that most fish in the pelagic zone are *O. nerka*. Gill net sets caught no fish. The pelagic fish and zooplankton communities of this lake are more typical of clear water lakes than stained, with *O. nerka* dominating and *Daphnia* present in good numbers. *Daphnia* was the most important diet item for age-0 *O. nerka*.

This lake has ample depth and a simple pelagic fish community, normally making it a good candidate for hydroacoustic surveys. However the presence of *Chaoborus* in the water column is a complicating factor. Modified *Chaoborus* techniques need to be considered both during data collection and data analysis (MacLellan and Hume 2010). As long as these modified techniques are employed and the *Chaoborus* densities are not too great, estimates of pelagic fish abundance are possible.

Kooryet Lake

Kooryet Lake is located on the north coast of British Columbia, on the eastern side of Banks Island, 4 km north of Keecha Lake. Due to the close proximity of these two lakes, they share many physical characteristics including having multiple basins with many islands and shoals. Kooryet Lake is about 6.2 km long, with an additional 2.5 km of outlet shallows (not surveyed) that drain a short distance to Principe Channel. We surveyed Kooryet with the Little Echo, using the 2x2 m trawl on September 1, 2008. Like most coastal lakes, Kooryet is a stained lake. We produced a bathymetric chart of the lake from the survey soundings (Fig. 3i).

Surprisingly, given this lake's close proximity to Keecha Lake, no *Chaoborus* larva were detected in Kooryet's water column, either in the SCOR net samples or by the echo sounder. The pelagic fish community of Kooryet Lake was much the same as found in Keecha Lake, a mixture of *O. nerka* and threespine stickleback, with each species vertically stratified and overlapping to some degree. Similar to Keecha, the stickleback of Kooryet were quite large, most being larger than age-0 *O. nerka* (Tables 3 and 4). *O. nerka* diet differed slightly from Keecha, in that the calanoid copepod, *Epischura*, was an important diet item for Kooryet *O. nerka*.

Like Keecha Lake, Kooryet is suitable for hydroacoustic assessment for *O. nerka* abundance, if considerable effort is spent on trawling to determine *O. nerka*/stickleback ratios in the various depth strata of each basin.

Kwinageese Lake

Kwinageese Lake lies in the Nass River watershed of northern British Columbia, about 78 km east of Stewart, B.C. It drains south 3.8 km, via the Kwinageese River, to Fred Wright Lake. We surveyed this lake on September 7, 2009 using the Little Echo and the 2x2m trawl. Kwinageese is classified as a clear lake. We used an existing bathymetric chart produced in 1996 for this survey (FIDQ).

Trawls and gill nets caught only three *O. nerka*; one each of age-0, age-1 and age-2+. The only other species caught in trawls were juvenile coho. Gill nets also caught rainbow trout, lake chub, and redside shiners (Tables 3 and 4). Hydroacoustics detected very few targets. Since the initial survey was conducted under a bright moon, to make sure this was not the source of a lack of targets, we resurveyed several transects the following night under overcast skies.

Subsequent analysis detected little difference between the first and second night's transects. No diet analysis was done due to the small sample size. Confidence of our estimate of around 6 000 *O. nerka* for the lake is low, given the low number of detections by the echo sounder and poor catch by our sampling gears. It is clear however, that there were very few juvenile *O. nerka* rearing in the lake in 2009, and many of them may well be kokanee given the presence of the older age classes captured in our gill nets and by Hill et al. (1997a, 1997b). Sockeye smolts were documented leaving the lake in the early 1990's, but recently beavers have heavily damned the outlet to Kwinageese River, making fry and adult sockeye access to the lake unlikely (Hall et al. In press).

Although a complicated bathymetry makes for an atypical survey design on this lake, hydroacoustics should be effective in estimating *O. nerka* abundance if they are present in greater numbers.

Lonesome Lake

Lonesome Lake is in the central interior, Bella Coola region, of British Columbia, about 72 km east of the town of Bella Coola, within Tweedsmuir Provincial Park. Part of the Atnarko River system, Lonesome Lake is just 14 km downstream from Elbow Lake. We surveyed Lonesome Lake with the Little Echo and the 2x2 m trawl. With its low turbidity readings, this lake was classified as clear, although there is some glacial influence to its waters. We used a Fish and Wildlife Branch bathymetric chart (FIDQ) drafted in 1976 for our survey design and lake volume calculations. Lonesome is approximately 9 km long, however, the first 4 km from the inlet end is relatively shallow (<6 m maximum depth) with many macrophytes present. It is unlikely that these shallows hold *O. nerka* in significant numbers. Therefore, these southern shallows were not included in the survey.

Trawls and gill nets caught 81 *O. nerka* in total. Most were age-0, but some were age-1 and age-2+ (Table 3), indicating a kokanee population is rearing in the lake as well as juvenile sockeye. We were not able to distinguish between age-0 sockeye and age-0 kokanee. Other species caught were sculpin, rainbow trout, cutthroat trout, and northern pikeminnow. Fish in the pelagic zone were dispersed, generally from 10 m to the bottom through the deep basin of the lake (Section 1). We estimated approximately 130 000 juvenile *O. nerka* in the lake. Lonesome Lake *O. nerka* fed mainly on *Daphnia*.

The deep basin of Lonesome lake is well suited for hydroacoustic assessment for juvenile sockeye. The challenge is distinguishing between juvenile sockeye and juvenile kokanee in trawl samples to apportion the *O. nerka* abundance estimate. There is a hint of bimodality in the length distribution within the trawl samples, but there is clearly much overlap. DNA or otolith strontium analysis would be needed to proportion sockeye/kokanee with any reasonable degree of confidence.

Meziadin Lake

Meziadin Lake is the rearing lake for the single largest sockeye stock in the Nass River System. It is located along the Cassiar Highway and approximately 45 km east of Stewart, B.C. We surveyed this lake on September 17, 2009, using the Night Echo (7.3 m cabin cruiser) and our 3x7 m trawl net. Although Meziadin is definitely glacially influenced, we classified it as clear due to relatively low turbidity readings (<5 NTU) (Table 1). For planning and lake volume calculation we used an existing bathymetric chart produced by the Fish and Wildlife Branch in 1972 (FIDQ).

Past surveys of this lake have been plagued with high 95% confidence limits in fish abundance estimates, most likely driven by the varied fish densities encountered in this relatively large lake. We found such fish distributions in our survey, with quite low densities in the northern section of the lake, and very high densities to the south. In order to try to constrain confidence limits, our survey design increased the number of transects from the six used in past surveys to ten. In addition we stratified the design, dividing the lake into two sections of five transects each. Even so, our *O. nerka* estimate of 9 000 000 has confidence limits on the high side at +/- 53% (Appendix 3).

We found that the vertical distribution of juvenile sockeye on most transects appeared to extend right up to the near surface ensonification limits of the transducer. This leaves the possibility that significant numbers of fish were present in the surface layers (0-2 m, 2-4 m) that are not detectable by the sounder due to transducer draft, transducer near field, and in this case surface noise that, at times, extended into the 2-4 m layer. This resulted in no useful acoustic information collected in these layers. Some acoustic information was gathered during trawls and since the transducer uses less draft during trawls and there is less surface noise, we were able estimate densities for the 2-4 m layer and gain some insight into their magnitude relative to adjacent layers. In section 1, densities from trawl soundings for the 2-4 m layer tended to be similar to the layer below, so we used densities from the layer below to estimate densities in the 2-4 m layer on transects. Similarly, for section 2, we found trawl acoustic densities for the 2-4 m layer to be roughly half that of the layer below, so for these transects, we used 50% of the density from the 4-6 m layer to estimate density in the 2-4 m layer. To estimate densities in the top layer (0-2 m) we looked to our surface trawls (1 in each section) for information. The net is 7 m deep so it fishes the top four layers (0-8 m) of the water column. After calculating expected catch from the lower 3 layers (2-8 m) using trawl acoustic densities and a net efficiency based on deeper trawls (~70%), we determined that our actual catch could be accounted for from the three lower layers alone. This was the case in both sections, suggesting few fish are in the top 2 m layer, so no density was applied to it.

Trawls caught 1 042 fish, that were all *O. nerka* except for one whitefish. The *O. nerka* catch was comprised of two age classes, 701 (67%) age-0 fish and 340 (33%) age-1 fish (Appendix 2). We retained 576 of these fish for lab processing and analysis; the remainder were quickly identified, counted, and released. The age classes were easily separated based on length using a frequency histogram, and were confirmed with scale ages. Generally, *Daphnia* were most important to the diet of Meziadin *O. nerka*, but Diacyclops, Eubosmina and insects also played a significant role (Appendix 5).

Hydroacoustic assessments of Meziadin Lake should produce reasonable estimates of juvenile sockeye abundance. Fish distribution on this lake, however, can lead to some difficulties in estimating abundance. When large differences in densities from one part of the lake to another occur, an increase in hydroacoustic sampling (number of transects) along with a stratified design can help keep the 95% confidence limits in check. We used a two section design, with five transects each, an increase of four transects over past surveys. Future surveys may want to further increase the number of transects to seven in each of these sections, 14 transects in all, to further reduce confidence intervals. Surveys on this lake should expect to have to deal with fish in the surface layers and have a strategy in place to sample and estimate densities, whether this is with trawl nets, side looking acoustics, or some other means. If using a trawl net, it would be best to have a smaller net available (3x3 m or 2x2 m) in order to sample only the surface layer(s).

Moore Lake

Moore Lake is situated on Pitt Island on the north coast of British Columbia, about 16 km west of Hartley Bay. It drains a short distance into Union Passage via Tsimtack Lake. Like most coastal lakes, Moore is classified as stained. Moore Lake has a somewhat complicated limnology due to a salt water layer occurring in the southern basin (Section 2) at about 20 m depth where salinity increases significantly and dissolved oxygen starts to decrease. The northern basin (Section 1) appears to consist of fresh water throughout the water column. We surveyed this lake on September 7, 2008 with the Little Echo and the 2x2 m trawl. We found no existing bathymetric chart for this lake, so we used our survey transect data along with addition transects and soundings to produce our own chart (Fig. 3j).

Trawls indicated a large stickleback population and that the upper 10-12 meters of the water column were predominately stickleback. *O. nerka* dominated in the deeper layers, below 16-20 meters, depending on lake section. Layers in between contained a mixture of the two species. Because of the shallow stickleback layer we estimated stickleback contamination of deeper trawls and adjusted the catch accordingly to calculate *O. nerka*/stickleback ratios. Most stickleback were smaller than the *O. nerka* in this lake, and there were two size classes of stickleback present; one centered around 52 mm, the other at 25 mm. This estimate was made assuming the sounder was able to detect all stickleback present. However, there was some concern that some or all of the smaller size class of stickleback were not detected at our analysis thresholds. If this was the case, the *O. nerka* to stickleback ratio will change significantly, leading to a higher *O. nerka* estimate. Our trawls caught 85 *O. nerka*, all age-0 fish, and 236 stickleback. Swedish gill nets caught an additional 20 stickleback (Appendix 2). *Chaoborus* larvae were found to be present in the lake, but did not occur in sufficiently high densities to significantly interfere with the hydroacoustic analyses. Both *O. nerka* and stickleback diet in Moore lake includes major contributions from insects with minor contributions from the zooplankters *Eubosmina* and *Holopedium*.

Hydroacoustic surveys of Moore Lake for juvenile sockeye abundance are definitely possible. Extra trawling effort is needed estimate sockeye/stickleback proportions and some research is needed to investigate the TS of small stickleback so researchers can better understand how to calculate these proportions, and how they apply to the acoustic estimates. As well, survey teams need to be aware of the meromictic nature of section 2 and to be prepared to deal with *Chaoborus* should densities increase to the point where they interfere with the hydroacoustic analysis. Transect 1 turned out to be quite shallow in depth (approx. 8 m max.) and likely holds only stickleback; it could possibly be moved or eliminated from the survey design.

Morice Lake

Morice Lake is in the interior Skeena region of British Columbia, about 65 km southwest of Houston, B.C. Morice drains some 425 km to the ocean via the Morice, Bulkley and Skeena rivers. We surveyed it on September 20, 2009 with the Night Echo and our 3x7 m trawl. We had previously surveyed Morice in 2002 (Hume and MacLellan 2008) and we used the same bathymetric chart and survey design. In Hume and MacLellan (2008) we classified Morice as glacial and it is certainly glacially influenced, however, under the criteria developed for this paper, it's turbidity of 3.5 NTU (Table 1) falls below 5 NTU, which qualifies it as a clear lake.

Morice is a lake of extremes among our study lakes. It's the largest and highest lake and has the longest migration route for sockeye of all the other study lakes in this paper. It is likely the least productive of the study lakes and ranks third for maximum depth, although the bathymetry of Morice lake is poorly surveyed and the estimate of maximum depth may be shallow.

During this survey we caught 22 *O. nerka*, mostly age-0 with a couple of age-1 fish, and one whitefish. However all of these fish were captured at a single location, in an isolated bay at the top end of Atna Bay (Transect 10) where, as in 2002, we found a typical layer of *O. nerka*. The rest of Morice Lake is a different story, with pelagic fish few and far between, and scattered throughout the water column. The vast majority of fish detected in the main lake were located along the slope bottom, not typical of an *O. nerka* distribution. The fish caught at transect 10 can hardly be considered representative of the whole lake. In 2002 we caught three fish in the main lake, and they were smaller than most of the fish caught at transect 10. In 2002, we found *O. nerka* at transect 10 to be feeding on *Holopedium* and insects. In 2009 they were feeding primarily on *Diacyclops* and *Bosmina* (Appendix 5).

With no fish samples from the main lake, and so few hydroacoustic detections in the pelagic zone, it is difficult to have much confidence in the 900 000 *O. nerka* estimate we arrived at, so our reliability rating is "very low" (Appendix 3). It is clear, however, that *O. nerka* densities in the main lake are extremely low. Until escapements to this lake system substantially increase, a 1-2 night hydroacoustic survey to assess the abundance of juvenile sockeye will likely fall short of producing reliable estimates. As a final note, our knowledge of the bathymetry of Morice Lake is very poor and a full bathymetric survey of the lake should be conducted.

Namu Lake

Namu Lake is located on the central coast of British Columbia, a short distance east of Namu B.C. The lake's outlet stream drains for a few hundred metres into Fitz Hugh Sound. We surveyed Namu, a stained lake, on September 15, 2006 using the Little Echo and the 2x2 m trawl. Finding no existing bathymetric chart for Namu Lake, we drew up our own from survey transects and additional soundings (Fig. 3k).

The trawl net caught 41 *O. nerka*, all age-0, and six stickleback. The stickleback were relatively large with a mean length of 76 mm (Table 4); in most cases larger than the *O. nerka*, which had a mean length of 55 mm (Table 3). *Chaoborus* larvae were present in this lake on most transects in sufficient numbers to interfere with regular hydroacoustic analysis, so we estimated *O. nerka* abundance at 177 000 fish using tracked target *Chaoborus* techniques as outlined in MacLellan and Hume (2010). The diet of Namu *O. nerka* was varied, but *Daphnia* was the main food item (Appendix 5).

Providing that *Chaoborus* densities do not increase to the point where distinguishing fish targets is too difficult, future surveys for juvenile sockeye abundance should provide reasonable estimates if the *Chaoborus* techniques mention above are used.

Red Bluff Lake

Red Bluff Lake is located on the east side of Pitt Island on the north coast of British Columbia, about 22 km west and slightly north of Hartley Bay. It drains a short distance into Grenville Channel, but the outlet creek has a barrier to anadromous fish. Like Batchellor Lake, we surveyed this lake on July 23, 2006 with the Little Echo and the 2x2 m trawl, as part of the Hanging lakes program, to evaluate existing fish stocks. We found no existing chart for this lake so we produced one using our transect hydroacoustic data along with some additional soundings (Fig. 3l). Red Bluff, like most coastal lakes, is stained.

Our midwater trawl caught 17 *O. nerka* (16 age-0, one age-1) and ten small larval fish. The larval fish were considered too small to be detected by the sounder at our analysis threshold, so their numbers were not applied to the hydroacoustic estimate. Swedish gill nets caught an additional five age-1 *O. nerka* and two age-2+ *O. nerka*. Since adult sockeye do not have access to the lake, these *O. nerka* must be kokanee, reproducing and rearing in Red Bluff Lake and its tributaries. Other fishing gear caught threespine stickleback, sculpin and cutthroat trout. Age-0 *O. nerka* preferred *Diaptomus* in their diet, while age-1 *O. nerka* selected *Bosmina* and *Holopedium* as well as *Diaptomus*.

Red bluff Lake is a good candidate for hydroacoustic assessment of *O. nerka* abundance. The current population of kokanee is of very low density, but their distribution within the lake is favorable to acoustic assessment and there is no reason planted sockeye fry would distribute differently. That, along with few similar sized other species in the pelagic zone, should make an *O. nerka* assessment fairly straightforward for this lake.

Tankeeah (lower) Lake

Lower Tankeeah Lake is situated on the Don Peninsula of British Columbia's central coast, about 21 km northwest of Bella Bella. It is drained by the Tankeeah River a short distance into Spiller Channel. Tankeeah Lower is made up of a complicated series of basins, bays and islands and is relatively shallow with a maximum depth of 29 m. We surveyed this lake on September 18, 2006 with the Little Echo and the 2x2 m trawl net. We drew a bathymetric chart of the lake from our various soundings of the lake (Fig. 3m). Like most of the coastal lakes we surveyed, this lake was classified as stained.

Of the 30 *O. nerka* captured during this survey, 29 were caught with the midwater trawl and all were age-0 fish. In addition, three stickleback and one coho were caught by various fishing gear. *Chaoborus* larvae were present in the lake and our *O. nerka* abundance estimate of 72 000 was arrived at by using tracked target and *Chaoborus* methods (MacLellan and Hume 2010). On most transects, *Chaoborus* densities were relatively low and did not pose much of a problem. *O. nerka* of Tankeeah Lower Lake were feeding mainly on *Bosmina* and *Holopedium* (Appendix 5), with some fish consuming *Chaoborus* larva as well.

As long as the *Chaoborus* methods above are employed and the *Chaoborus* population remains at current levels, hydroacoustic assessments of this lake should produce reasonably good estimates of *O. nerka* abundance.

Tankeeah (upper) Lake

Upper Tankeeah Lake is just north of Lower Tankeeah Lake and the two are connected by a creek approximately 150 m in length. We surveyed this lake on September 19, 2006, the next night after completing the lower lake survey, using the same gear. Again, we created our own bathymetric chart from our hydroacoustic soundings (Fig. 3n). This lake is also classified as stained.

We caught only four *O. nerka*, all age-0 fish, from this lake along with seven stickleback, and all from midwater trawls. With such a low catch we pooled the trawl results and applied them to the entire lake rather than on a section by section basis. Like Tankeeah Lower Lake, *Chaoborus* were present in the upper lake and hydroacoustic data was handled in the same manner to produce an *O. Nerka* estimate of 43 000 fish (Appendix 3). Diet differed in the upper lake in that *Diaptomus* was the most important food item followed by *Bosmina*. It is important to note however, that this is based on analysis of only three fish. (Appendix 5).

As with the lower lake, surveys of Upper Tankeeah should produce good estimates of *O. nerka* abundance using *Chaoborus* methods. A higher trawl catch would be desirable, to better estimate sockeye and stickleback ratios in each of the basins (sections 1 and 2), thus more emphasis on trawling may be required.

Whalen Lake

Whalen is a relatively large lake (24 km long) located on Princess Royal Island, about 25 km south east of Hartley Bay, and in the north coast region of British Columbia. This stained lake is drained by Whalen Creek, less than 1 km into Whale Channel. The drop from lake level to sea level is over 100 m and there is a barrier on the creek preventing anadromous fish from reaching the lake. We surveyed Whalen for the hanging lakes program on July 26, 2006 with the Little Echo and our 2x2m trawl and used an existing bathymetric chart drawn up for the Ministry of Environment, Lands and Parks in 1996 (FIDQ).

Only one fish, an age-1 *O. nerka*, was caught in 100 minutes of trawling. Gill nets caught nine age-1 *O. nerka* along with several Dolly Varden trout and one coho salmon. We found our gill nets were more successful catching *O. nerka* when deployed in the littoral zone of the lake, suggesting the *O. nerka*, in this case kokanee, were utilizing the near shore areas of the lake more than is typical of *O. nerka* populations. Dense layers of *Chaoborus* larvae were present on most transects, dense enough to pose some difficulties for the analysis even using tracked target *Chaoborus* techniques (MacLellan and Hume 2010). Many of the fish targets detected in the pelagic zone were larger fish, most likely Dolly Varden and larger kokanee. Some small fish, juvenile *O. nerka* sized, may be hidden amongst the *Chaoborus* signal, but they are unlikely to be there in significant numbers, as indicated by the lack of catch in our midwater trawls. With no evidence of other species in the small fish category in the pelagic zone, we attributed all fish in that category to the juvenile kokanee estimate of 159 000 fish (Appendix 3). It should be noted however, that if kokanee in this lake are shore oriented, we would have missed a significant portion of the population, as our sampling design does not adequately sample the near shore area. No diet workup was done for this lake due to the low trawl catch (one fish).

Hydroacoustic assessments of this lake have two challenges. The first is to separate fish targets from *Chaoborus* targets in the pelagic zone. *Chaoborus* densities were fairly high for this survey and any significant increase in these densities would certainly hamper analysis efforts. The second involves the apparent preference of the existing kokanee population for near shore habitat. Assessing littoral fish populations with acoustics is more difficult than pelagic assessments, requiring more time and effort to adequately sample the population and analyze the data. Why these kokanee prefer the near shore habitat is unclear. Zooplankton densities in the pelagic zone, although on the low side (ranked 14th among our 20 study lakes), are not excessively so (Appendix 6). Perhaps it is competition with the *Chaoborus* population that forces them inshore. In any case, at this point it is unclear whether an introduced population of juvenile sockeye would follow the norm and inhabit the pelagic zone of Whalen Lake or move into the near shore habitat like the existing kokanee population.

Appendix 2. Record of trawls and sets completed during surveys of the study lakes.

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
Alastair	Trawl 2mx2m	13-Sep-09	23:40	1	15	1	1	Contin. rain	Light breeze	Threespine stickleback	26
		14-Sep-09	20:29	1	15	8	8	>50% cloud	Light air	Age-0 *O. nerka*	1
										Age-1 *O. nerka*	1
										Threespine stickleback	354
		14-Sep-09	20:59	1	30	14	14	>50% cloud	Light air	Age-0 *O. nerka*	1
										Age-1 *O. nerka*	2
										Threespine stickleback	31
		14-Sep-09	21:42	1	30	19	19	>50% cloud	Light air	Age-0 *O. nerka*	2
										Age-1 *O. nerka*	3
										Threespine stickleback	5
		14-Sep-09	22:23	1	35	30	30	>50% cloud	Light air	Age-0 *O. nerka*	1
										Threespine stickleback	14
		14-Sep-09	23:16	1	30	24	24	>50% cloud	Light air	Age-1 *O. nerka*	2
										Threespine stickleback	12
		15-Sep-09	0:48	2	20	1	1	Fog/haze	Light air	Threespine stickleback	4
		15-Sep-09	1:26	2	20	6	6	Fog/haze	Light air	Age-0 *O. nerka*	1
										Age-1 *O. nerka*	1
										Threespine stickleback	62
		15-Sep-09	2:01	2	20	12.5	12.5	Fog/haze	Light air	Age-0 *O. nerka*	18
										Age-1 *O. nerka*	13
										Threespine stickleback	138
		15-Sep-09	2:36	2	25	12.5	12.5	Fog/haze	Light air	Age-0 *O. nerka*	20
										Age-1 *O. nerka*	7
										Threespine stickleback	208
		15-Sep-09	3:15	2	20	18	18	Contin. rain	Light air	Age-0 *O. nerka*	3
										Age-1 *O. nerka*	20
										Threespine stickleback	128
	Swedish gill net	13-Sep-09	16:34	2	997	11	11			Age-1 *O. nerka*	1
										Threespine stickleback	4
		13-Sep-09	16:53	1	993	10.5	10.5			Threespine stickleback	1

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
		14-Sep-09	20:40	2	445	7	7			Age-0 *O. nerka*	1
										Age-1 *O. nerka*	1
		14-Sep-09	20:55	2	440	14	14				0
Batchellor	Trawl 2mx2m	21-Jul-06	22:53	1	15	8	8	<10% cloud	Light air		0
		21-Jul-06	23:16	1	30	27	29	<10% cloud	Light air		0
	Swedish gill net	20-Jul-06	18:27	1	976	9	10.5				0
		20-Jul-06	19:05	1	948	9	10.5			Dolly Varden	1
		21-Jul-06	10:45	1	1448	9	10.5				0
		21-Jul-06	11:00	1	1405	9	10.5				0
	RIC gill net	20-Jul-06	15:27	1	1054	0	2			Cutthroat trout	37
										Dolly Varden	1
		20-Jul-06	17:59	1	959	0	2			Cutthroat trout	19
										Dolly Varden	2
	Minnow trap	20-Jul-06	16:13	1	947	1.5	1.5			Dolly Varden	2
		20-Jul-06	16:17	1	976	2	2			Dolly Varden	1
		20-Jul-06	16:23	1	976	1.7	1.7				0
		20-Jul-06	16:26	1	982	2	2			Dolly Varden	1
		20-Jul-06	16:33	1	981	0.5	0.5			Dolly Varden	1
	Beach seine	20-Jul-06	21:45	1		0	1	>50% cloud	Calm	Cutthroat trout	6
										Dolly Varden	2
		21-Jul-06	19:50	1		0	1			Cutthroat trout	11
										Dolly Varden	1
		21-Jul-06	20:15	1		0	1			Cutthroat trout	2
		21-Jul-06	20:40	1		0	1				0
Bowser	Trawl 2mx2m	04-Sep-09	23:16	1	40	1	1	10-50% cloud	Light air	Age-0 *O. nerka*	1
										Age-1 *O. nerka*	1
		05-Sep-09	1:23	1	40	3	3	10-50% cloud	Light air	Age-0 *O. nerka*	2
		05-Sep-09	2:25	1	25	5	5	10-50% cloud	Light air		0
		06-Sep-09	1:09	1	30	1	1	Fog/haze	Light air	Age-1 *O. nerka*	3

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

Lake	Gear	Date	Time	Section	Duration (min)	Depth (m)		Conditions		Catch	
						Start	End	Sky	Wind	Taxa	N
		06-Sep-09	1:13	2	30	3	3	Fog/haze	Light breeze	Age-1 *O. nerka*	3
										Age-2+ *O. nerka*	1
		06-Sep-09	21:27	2	10	1	1	>50% cloud	Light air	Age-0 *O. nerka*	3
										Age-1 *O. nerka*	3
		06-Sep-09	21:59	2	7	1	1	>50% cloud	Light air	Age-0 *O. nerka*	1
										Age-1 *O. nerka*	2
		06-Sep-09	22:32	2	10	1.5	1.5	>50% cloud	Light air	Age-0 *O. nerka*	10
										Age-1 *O. nerka*	4
										Age-2+ *O. nerka*	2
		06-Sep-09	23:03	2	17	1.5	1.5	>50% cloud	Light air	Age-0 *O. nerka*	4
										Age-1 *O. nerka*	5
		06-Sep-09	23:44	2	17	1.5	1.5	>50% cloud	Light air	Age-0 *O. nerka*	2
		07-Sep-09	0:24	2	30	1	1	>50% cloud	Light air	Age-0 *O. nerka*	1
		07-Sep-09	1:16	2	20	1	1	>50% cloud	Light air	Age-0 *O. nerka*	1
		07-Sep-09	1:51	2	20	3	3	>50% cloud	Light air		0
	Swedish gill net	04-Sep-09	15:27	2	1217	5	5				0
		04-Sep-09	15:40	2	1214	2.5	2.5			Age-1 *O. nerka*	6
		04-Sep-09	15:56	2	1209	3	3			Age-1 *O. nerka*	1
										Bull trout	1
		04-Sep-09	16:28	2	1952	3	3				0
		05-Sep-09	15:22	2	1294	1	1			Age-1 *O. nerka*	5
										Age-2+ *O. nerka*	6
										Coho salmon	1
										Adult/jack sockeye	1
		05-Sep-09	11:58	2	1472	2.5	2.5			Age-2+ *O. nerka*	1
		05-Sep-09	12:08	2	1492	3	3				0
		05-Sep-09	12:35	2	1485	0.5	0.5			Age-1 *O. nerka*	1
		06-Sep-09	13:29	2	1151	0.5	0.5			Age-1 *O. nerka*	3
										Sucker	1
		06-Sep-09	13:40	2	1150	1	1			Age-0 *O. nerka*	1
										Age-1 *O. nerka*	2

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
		06-Sep-09	13:54	2	1157	0.5	0.5			Age-0 *O. nerka*	3
										Age-1 *O. nerka*	24
										Age-2+ *O. nerka*	6
										Bull trout	2
										Coho salmon	2
										Adult/jack sockeye	1
		06-Sep-09	14:03	2	1167	0.5	0.5			Age-0 *O. nerka*	3
										Age-1 *O. nerka*	20
										Age-2+ *O. nerka*	8
										Bull trout	1
										Coho salmon	2
Elbow	Trawl 2mx2m	20-Sep-07	21:34	1	18	15	15	<10% cloud	Light air	Age-0 *O. nerka*	2
										Coho salmon	1
		20-Sep-07	22:09	1	14	16	16	<10% cloud	Light breeze	Age-0 *O. nerka*	5
		20-Sep-07	22:36	1	19	14	14	10-50% cloud	Light breeze	Age-0 *O. nerka*	2
		20-Sep-07	23:21	1	10	20	20	>50% cloud	Light breeze	Age-0 *O. nerka*	2
		20-Sep-07	23:47	1	19	1	1	Intermit. rain	Light breeze	Sculpin	5
	Swedish gill net	19-Sep-07	18:10	1	965	14	14			Age-0 *O. nerka*	2
		19-Sep-07	19:10	1	870	15	15			Age-0 *O. nerka*	1
										Age-2+ *O. nerka*	3
		20-Sep-07	10:00	1	1350	15	15			Age-0 *O. nerka*	1
										Age-2+ *O. nerka*	1
		20-Sep-07	10:25	1	1385	14	14			Age-0 *O. nerka*	3
										Age-1 *O. nerka*	1
										Age-2+ *O. nerka*	1
		20-Sep-07	14:00	2	1290	2	2			Northern pikeminnow	3

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
Fred Wright	Trawl 2mx2m	10-Sep-09	0:04	1	50	7	7	>50% cloud	Gentle breeze		0
		10-Sep-09	21:24	1	19	8	8	Contin. rain	Calm	Age-0 *O. nerka*	2
										Sculpin	2
		10-Sep-09	23:08	1	28	1	1	Contin. rain	Light breeze		0
		10-Sep-09	23:57	1	30	12	12	Contin. rain	Light breeze		0
	Swedish gill net	09-Sep-09	20:01	1	889	7	7			Age-0 *O. nerka*	1
										Age-1 *O. nerka*	3
		09-Sep-09	20:21	1	930	5	5				0
		09-Sep-09	20:39	1	934	7	7			Age-0 *O. nerka*	1
		09-Sep-09	20:51	1	935	4	4				0
		10-Sep-09	12:15	1	1152	12	12				0
		10-Sep-09	12:30	1	1210	8	8				0
		10-Sep-09	12:45	1	1208	10	10				0
		10-Sep-09	12:50	1	1211	8	8			Age-1 *O. nerka*	1
										Bull trout	1
Keecha	Trawl 2mx2m	04-Sep-08	21:35	1	5	10	8	Intermit. rain	Light breeze	Age-0 *O. nerka*	11
										Threespine stickleback	5
										Adult/jack sockeye	1
		04-Sep-08	22:00	1	11	14	14	Intermit. rain	Light breeze	Age-0 *O. nerka*	66
										Age-1 *O. nerka*	2
										Threespine stickleback	2
										Dolly Varden	1
		04-Sep-08	22:30	1	10	10	10	Intermit. rain	Light breeze	Age-0 *O. nerka*	16
										Age-1 *O. nerka*	1
										Threespine stickleback	10
		04-Sep-08	22:51	1	10	18	18	Intermit. rain	Light breeze	Age-0 *O. nerka*	29
										Age-1 *O. nerka*	1
		04-Sep-08	23:13	1	10	6	6	Intermit. rain	Light breeze	Age-0 *O. nerka*	1
										Threespine stickleback	21

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
		04-Sep-08	23:41	1	10	1	1	Intermit. rain	Light breeze	Age-0 *O. nerka*	2
										Threespine stickleback	18
		05-Sep-08	22:41	4	5	11	11	<10% cloud	Calm	Age-0 *O. nerka*	1
										Prickly sculpin	1
		05-Sep-08	23:03	4	10	11	11	<10% cloud	Calm	Age-0 *O. nerka*	13
										Threespine stickleback	1
		05-Sep-08	23:27	3	10	11	10	<10% cloud	Calm	Age-0 *O. nerka*	7
										Threespine stickleback	1
		05-Sep-08	23:52	3	7	14	14	<10% cloud	Calm	Age-0 *O. nerka*	32
										Age-1 *O. nerka*	1
										Threespine stickleback	2
		06-Sep-08	0:15	4	7	14	14	<10% cloud	Calm	Age-0 *O. nerka*	19
										Threespine stickleback	1
		06-Sep-08	0:34	4	10	4	4	<10% cloud	Calm	Threespine stickleback	5
		06-Sep-08	0:58	3	10	1	1	<10% cloud	Calm	Threespine stickleback	3
	Swedish gill net	04-Sep-08	13:00	3	1308	12	12				0
		04-Sep-08	13:42	4	1493	13	13				0
		04-Sep-08	15:35	2	1167	13	13			Threespine stickleback	1
		04-Sep-08	16:08	2	1152	12	12				0
		04-Sep-08	16:53	1	1120	13	13				0
		04-Sep-08	11:11	2	1419	12	12				0
		05-Sep-08	11:00	2	1423	13	13				0
		05-Sep-08	11:15	2	1392	14	14				0
		05-Sep-08	12:30	2	1323	15	15				0
		06-Sep-08	14:40	4	1240	14	14				0
Kimsquit	Trawl 2mx2m	13-Sep-07	20:49	1	25	6	6	<10% cloud	Calm	Age-0 *O. nerka*	13
		13-Sep-07	22:07	1	40	7	8	<10% cloud	Calm	Age-0 *O. nerka*	9
		13-Sep-07	23:46	1	30	7	7	<10% cloud	Calm	Age-0 *O. nerka*	10
										Sculpin	1
		14-Sep-07	0:43	1	20	20	20	<10% cloud	Light air	Age-0 *O. nerka*	1

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

Lake	Gear	Date	Time	Section	Duration (min)	Depth (m) Start	Depth (m) End	Conditions Sky	Conditions Wind	Catch Taxa	Catch N
		14-Sep-07	1:27	1	15	1	1	<10% cloud	Light air		0
	Swedish gill net	12-Sep-07	21:16	1	954	5	5				0
		12-Sep-07	21:50	1	940	7	7			Age-0 *O. nerka*	8
										Age-1 *O. nerka*	6
		13-Sep-07	19:04	1	916	7	7			Age-0 *O. nerka*	1
		13-Sep-07	19:16	1	883	5	5			Age-1 *O. nerka*	2
Kitlope	Trawl 2mx2m	15-Sep-07	21:43	1	45	3	3	Contin. rain	Light breeze	Age-0 *O. nerka*	16
										Age-1 *O. nerka*	3
		15-Sep-07	22:50	1	20	1.3	1.3	Contin. rain	Light breeze	Age-0 *O. nerka*	23
										Age-1 *O. nerka*	5
										Threespine stickleback	2
		16-Sep-07	22:03	1	55	2	2	10-50% cloud	Light breeze	Age-0 *O. nerka*	61
										Age-1 *O. nerka*	3
	Swedish gill net	15-Sep-07	17:42	1	1032	2	2			Age-0 *O. nerka*	2
										Age-1 *O. nerka*	5
		15-Sep-07	18:10	1	1013	3	3			Age-1 *O. nerka*	9
										Age-2+ *O. nerka*	1
		16-Sep-07	12:00	1	1460	0	0	Contin. rain	Light breeze		0
		16-Sep-07	10:54	1	1456	2	2				0
		16-Sep-07	11:05	1	1432	3	3			Threespine stickleback	1
										Coho salmon	1
		16-Sep-07	12:05	1	1555	0	0			Age-0 *O. nerka*	4
										Age-1 *O. nerka*	5
										Coho salmon	1
Koeye	Trawl 2mx2m	12-Sep-06	21:07	1	25	10	10	<10% cloud	Light air	Age-0 *O. nerka*	14
										Threespine stickleback	1
		12-Sep-06	22:20	2	30	12	12	<10% cloud	Light air	Age-0 *O. nerka*	56

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
	Swedish gill net	13-Sep-06	18:33	2	842	10	10				0
		13-Sep-06	19:17	1	808	10	10				0
Kooryet	Trawl 2mx2m	02-Sep-08	20:46	3	16	10	10	<10% cloud	Calm	Age-0 *O. nerka*	11
		02-Sep-08	21:30	3	10	13	13	<10% cloud	Calm	Age-0 *O. nerka*	7
										Threespine stickleback	1
		02-Sep-08	21:52	3	10	7	7	<10% cloud	Calm	Threespine stickleback	3
		02-Sep-08	22:28	2	12	11	11	<10% cloud	Calm	Age-0 *O. nerka*	2
										Threespine stickleback	3
		02-Sep-08	22:54	1	30	14	14	<10% cloud	Calm	Age-0 *O. nerka*	39
										Age-1 *O. nerka*	1
										Threespine stickleback	27
		02-Sep-08	23:45	1	30	20	20	<10% cloud	Calm	Age-0 *O. nerka*	6
										Threespine stickleback	1
		02-Sep-08	0:43	1	20	8	8	<10% cloud	Calm	Threespine stickleback	4
		02-Sep-08	0:49	2	15	1	1	<10% cloud	Calm	Threespine stickleback	5
	Swedish gill net	01-Sep-08	15:25	2	1115	10.5	10.5				0
		01-Sep-08	16:51	1	1029	8	8				0
		01-Sep-08	17:05	1	1025	9	9				0
		01-Sep-08	17:21	2	1020	9	9			Threespine stickleback	1
		01-Sep-08	18:05	3	945	8	8				0
		02-Sep-08	10:55	1	1488	14	14				0
		02-Sep-08	11:09	1	1521	11	11				0
		02-Sep-08	11:25	2	1476	12	12				0
	Small mesh gill net	02-Sep-08	10:04	3	1501	12	12				0
		02-Sep-08	10:24	2	1506	16	16				0
Kwinageese	Trawl 2mx2m	08-Sep-09	22:14	1	31	10	10	Contin. rain	Light air	Coho salmon	2
		09-Sep-09	0:02	1	18	30	30	Contin. rain	Light air	Age-1 *O. nerka*	1

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
		09-Sep-09	0:46	1	30	24	24	Contin. rain	Light air		0
		09-Sep-09	1:27	1	30	6	6	Contin. rain	Light air	Age-0 *O. nerka*	1
										Coho salmon	2
		09-Sep-09	2:10	1	30	1	1	Contin. rain	Light air		0
	Swedish gill net	07-Sep-09	20:06	1	749	5	5			Rainbow trout	1
		07-Sep-09	23:05	1	744	6	6			Age-2+ *O. nerka*	1
		07-Sep-09	21:01	1	734	6	6			redside shiner	13
										Lake chub	4
		07-Sep-09	21:31	1	779	5	5			Redside shiner	49
										Lake chub	1
		08-Sep-09	8:50	1	1498	10	10				0
		08-Sep-09	11:18	1	1361	8	8			Redside shiner	1
		08-Sep-09	11:35	1	1353	7	7				0
		08-Sep-09	11:55	1	1340	7	7				0
Lonesome	Trawl 2mx2m	08-Sep-07	23:25	1	20	15	16	<10% cloud	Light breeze	Age-0 *O. nerka*	9
		09-Sep-07	0:08	1	20	30	30	<10% cloud	Light breeze	Age-0 *O. nerka*	1
										prickly sculpin	3
		09-Sep-07	0:53	1	20	24	24	<10% cloud	Light breeze	Age-0 *O. nerka*	3
										Age-1 *O. nerka*	1
										Sculpin	2
		09-Sep-07	1:30	1	20	19	19	<10% cloud	Calm	Age-0 *O. nerka*	3
										Age-1 *O. nerka*	1
										Sculpin	1
		11-Sep-07	20:50	1	20	16	16	<10% cloud	Gentle breeze	Age-0 *O. nerka*	14
										Age-1 *O. nerka*	1
		11-Sep-07	21:31	1	25	17	17	<10% cloud	Gentle breeze	Age-0 *O. nerka*	18
		11-Sep-07	22:17	1	15	16	19	<10% cloud	Gentle breeze	Age-0 *O. nerka*	15
		11-Sep-07	22:47	1	20	1	1	<10% cloud	Gentle breeze		0

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
	Swedish gill net	08-Sep-07	15:38	1	1228	15	15	<10% cloud		Age-0 *O. nerka*	2
										Age-1 *O. nerka*	1
										Rainbow trout	1
		08-Sep-07	16:15	1	1216	15	15			Age-0 *O. nerka*	2
		11-Sep-07	12:51	1	1059	17	17	<10% cloud		Age-0 *O. nerka*	7
										Age-2+ *O. nerka*	3
										Cutthroat trout	1
	Dip net	11-Sep-07				0	1			Northern pikeminnow	1
										Prickly sculpin	1
Meziadin	Trawl 3mx7m	17-Sep-09	21:47	2	20	10	10	Contin. rain	Light breeze	Age-0 *O. nerka*	281
										Age-1 *O. nerka*	27
		17-Sep-09	22:53	2	15	21	21	Contin. rain	Light breeze	Age-0 *O. nerka*	208
										Age-1 *O. nerka*	144
		18-Sep-09	0:03	2	15	3.5	3.5	Contin. rain	Light breeze	Age-0 *O. nerka*	126
										Age-1 *O. nerka*	2
		18-Sep-09	22:19	1	20	3.5	3.5	Contin. rain	Light breeze	Age-0 *O. nerka*	11
										Whitefish	1
		18-Sep-09	23:24	1	20	11	11	>50% cloud	Light breeze	Age-0 *O. nerka*	70
										Age-1 *O. nerka*	146
		18-Sep-09	0:21	1	10	19	19	>50% cloud	Light breeze	Age-0 *O. nerka*	5
										Age-1 *O. nerka*	21
Moore	Trawl 2mx2m	07-Sep-08	22:06	2	20	14	14	Intermit. rain	Light air	Age-0 *O. nerka*	17
										Threespine stickleback	1
		07-Sep-08	22:52	2	20	9	9	>50% cloud	Light air	Threespine stickleback	13
		07-Sep-08	23:25	2	17	18	20	>50% cloud	Light air	Age-0 *O. nerka*	8
										Threespine stickleback	2
		07-Sep-08	23:53	2	15	14	12	>50% cloud	Light air	Age-0 *O. nerka*	13
										Threespine stickleback	4
		08-Sep-08	20:45	1	10	13	13	<10% cloud	Gentle breeze	Age-0 *O. nerka*	9

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

Lake	Gear	Date	Time	Section	Duration (min)	Depth (m) Start	Depth (m) End	Conditions Sky	Conditions Wind	Catch Taxa	Catch N
										Threespine stickleback	45
		08-Sep-08	21:15	1	22	17	17	<10% cloud	Moderate breeze	Age-0 *O. nerka*	25
										Threespine stickleback	9
		08-Sep-08	22:08	1	16	22	26	<10% cloud	Gentle breeze	Age-0 *O. nerka*	13
										Threespine stickleback	5
		08-Sep-08	22:43	1	15	9	9	<10% cloud	Gentle breeze	Threespine stickleback	111
		08-Sep-08	23:21	1	20	1	1	<10% cloud	Gentle breeze	Threespine stickleback	46
	Swedish gill net	07-Sep-08	13:18	2	1413	10	10			Threespine stickleback	3
		07-Sep-08	14:28	1	1320	13	13				0
		07-Sep-08	15:24	1	1354	5	5			Threespine stickleback	7
		08-Sep-08	13:30	1	1214	20	20				0
		08-Sep-08	13:40	1	1217	16	16				0
		08-Sep-08	14:15	1	1193	7	7			Threespine stickleback	10
	Small mesh gill net	07-Sep-08	13:29	2	1409	13	13				0
		07-Sep-08	15:50	1	1320	12	12				0
		08-Sep-08	13:11	2	1224	13	13				0
		08-Sep-08	13:55	1	1197	18	18				0
Morice	Trawl 3mx7m	22-Sep-09	23:35	3	15	17	17	<10% cloud	Light air	Age-0 *O. nerka*	6
										Age-1 *O. nerka*	2
										whitefish	1
		23-Sep-09	0:21	3	15	24	24	<10% cloud	Light air	Age-0 *O. nerka*	2
		23-Sep-09	1:07	3	25	18	18	<10% cloud	Light air	Age-0 *O. nerka*	12
Namu	Trawl 2mx2m	15-Sep-06	20:36	2	13	8	8	<10% cloud	Light breeze	Age-0 *O. nerka*	6
										Threespine stickleback	2
		15-Sep-06	21:51	2	15	9	9	<10% cloud	Light air	Age-0 *O. nerka*	8
		15-Sep-06	23:48	1	35	11	10	10-50% cloud	Light air	Age-0 *O. nerka*	27
										Threespine stickleback	4
	Swedish gill net	15-Sep-06	19:05	1	930	7	8.5				0
		15-Sep-06	19:25	2	1129	7	8.5			Age-0 *O. nerka*	2

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

Lake	Gear	Date	Time	Section	Duration (min)	Depth (m)		Conditions		Catch	
						Start	End	Sky	Wind	Taxa	N
Red Bluff	Trawl 2mx2m	23-Jul-06	23:05	3	30	10	10	<10% cloud	Calm		0
		24-Jul-06	1:10	2	10	12	12	<10% cloud	Calm	Age-0 *O. nerka*	3
		24-Jul-06	1:42	2	30	12	12	<10% cloud	Calm	Age-0 *O. nerka*	4
										Larval fish	5
		24-Jul-06	22:47	2	30	12	12	Intermit. rain	Light breeze	Age-0 *O. nerka*	2
										Larval fish	3
		24-Jul-06	23:39	2	20	14	14	Intermit. rain	Light air	Age-0 *O. nerka*	4
										Larval fish	2
		25-Jul-06	0:58	1	10	10	12	Intermit. rain	Light air	Age-0 *O. nerka*	2
										Age-1 *O. nerka*	1
		25-Jul-06	1:25	1	8	10	10	>50% cloud	Light air	Age-0 *O. nerka*	1
	Swedish gill net	23-Jul-06	20:34	1	909	10	11.5			Age-1 *O. nerka*	5
										Age-2+ *O. nerka*	2
										Cutthroat trout	2
		23-Jul-06	20:57	2	1073	10	11.5			Cutthroat trout	1
		24-Jul-06	14:58	2	1167	10	11.5				0
	RIC gill net	23-Jul-06	12:20	1	415	0	2			Cutthroat trout	6
		23-Jul-06	13:38	1	386	0	2			Cutthroat trout	7
		24-Jul-06	14:31	2	331	0	2			Cutthroat trout	5
		24-Jul-06	16:52	2	1013	0	2			Cutthroat trout	5
		24-Jul-06	20:15	2	760	0	2			Cutthroat trout	3
	Minnow trap	23-Jul-06	13:45	1	1331	1	1			Threespine stickleback	15
		23-Jul-06	13:55	1	1330	2	2			Threespine stickleback	6
		23-Jul-06	14:03	1	1331	0.5	0.5			Threespine stickleback	27
		23-Jul-06	14:12	1	1332	1.5	1.5			Threespine stickleback	37
		23-Jul-06	14:20	2	1365	1	1			Threespine stickleback	14
		24-Jul-06	14:22	2	1133	2	2			Threespine stickleback	7
										Sculpin	2
		24-Jul-06	14:35	2	1130	2.5	2.5				0
		24-Jul-06	14:46	2	120	0	2			Cutthroat trout	1

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

Lake	Gear	Date	Time	Section	Duration (min)	Depth (m) Start	Depth (m) End	Conditions Sky	Conditions Wind	Catch Taxa	Catch N
		24-Jul-06	16:51	2	1074	1	1			Threespine stickleback	4
		24-Jul-06	17:00	2	1058	1	1			Threespine stickleback	12
										Sculpin	2
		24-Jul-06	17:04	2	1046	1	1				0
	Dip net	25-Jul-06	8:00	2		0.5	0.5			Sculpin	1
	Beach seine	25-Jul-06	15:00	2		0	1.5			Threespine stickleback	59
										Sculpin	6
Tankeeah (lower)	Trawl 2mx2m	18-Sep-06	20:43	3	7	7	7	>50% cloud	Light air		0
		18-Sep-06	21:05	3	10	7	7	>50% cloud	Light air	Age-0 *O. nerka*	5
										Threespine stickleback	1
		18-Sep-06	21:31	3	13	9	7	>50% cloud	Light air	Age-0 *O. nerka*	14
		18-Sep-06	23:25	2	7	6	7	>50% cloud	Light air	Age-0 *O. nerka*	10
										Threespine stickleback	1
		18-Sep-06	0:07	1	8	8	6	10-50% cloud	Light air		0
	Swedish gill net	18-Sep-06	19:15	2	920	4	5.5				0
		18-Sep-06	19:35	3	910	5	6.5			Age-0 *O. nerka*	1
										Threespine stickleback	1
										Coho salmon	1
Tankeeah (upper)	Trawl 2mx2m	19-Sep-06	21:52	1	4	8	5	Contin. rain	Light air	Age-0 *O. nerka*	1
		19-Sep-06	22:04	1	7	8.5	8.5	Contin. rain	Light air	Age-0 *O. nerka*	3
										Threespine stickleback	6
		19-Sep-06	23:11	2	9	7.5	7.5	Contin. rain	Light air	Threespine stickleback	1
	Swedish gill net	19-Sep-06	18:55	1	830	7	8.5				0
		19-Sep-06	19:10	2	780	7	8.5				0
Whalen	Trawl 2mx2m	27-Jul-06	0:06	1	30	11	11	>50% cloud	Light breeze		0
		27-Jul-06	2:06	1	30	12	15	>50% cloud	Light breeze	Age-1 *O. nerka*	1
		27-Jul-06	22:23	2	20	10	10	>50% cloud	Light air		0
		28-Jul-06	0:05	2	20	12	12	<10% cloud	Light air		0

Appendix 2. Record of trawls and sets completed during surveys of the study lakes (Continued).

					Duration	Depth (m)		Conditions		Catch	
Lake	Gear	Date	Time	Section	(min)	Start	End	Sky	Wind	Taxa	N
	Swedish gill net	26-Jul-06	12:38	1	1344	8.5	10				0
		26-Jul-06	12:53	1	1342	8.5	10			Age-1 *O. nerka*	1
		27-Jul-06	11:05	1	1400	8.5	10				0
		27-Jul-06	17:50	1	965	0	1.5				0
		27-Jul-06	11:00	2	1405	8.5	10				0
	RIC gill net	26-Jul-06	10:58	1	1547	0	2			Coho salmon	1
										Dolly Varden	12
		26-Jul-06	11:31	1	1494	0	2			Age-1 *O. nerka*	6
										Dolly Varden	2
		27-Jul-06	12:00	2	1295	0	2			Dolly Varden	5
		27-Jul-06	12:50	1	1265	0	2			Age-1 *O. nerka*	2
	Minnow trap	26-Jul-06	11:03	1	1502	1.5	1.5			Dolly Varden	1
		26-Jul-06	11:06	1	1504	0.5	0.5			Dolly Varden	3
		26-Jul-06	11:09	1	1506	2	2			Dolly Varden	1
		26-Jul-06	11:35	1	1515	1	1			Dolly Varden	3
		26-Jul-06	11:37	1	1523	1	1			Dolly Varden	1
		27-Jul-06	12:08	1	222	0.5	0.5				0
		27-Jul-06	12:10	1	215	0.5	0.5				0
		27-Jul-06	12:15	1	205	1	1				0

Appendix 3. Hydroacoustic estimates of pelagic fish populations.

		Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability
				95%			95%			95%	of
Lake	Analysis	N	(N/ha)	CI	N	(N/ha)	CI	N	(N/ha)	CI	Estimate
Alastair	Integration [a]	371,654	544	31	3,985,014	5,836	36	62,945	92	44	Medium
	Single targets	387,025	567	31	3,973,694	5,819	37	59,409	87	41	Medium
	Tracked targets	412,185	604	32	4,004,647	5,865	37	58,666	86	40	Medium
Batchelor	Tracked targets CHA [a]	-	-		86,154	150	50	14,800	26	71	Medium
Bowser	Tracked targets/trawl [a]	131,668	39	13	-	-		822	0.2	143	Very low
Elbow	Integration	16,194	155	58	1,466	14	58	10,018	96	64	Medium
	Single targets	15,438	147	74	1,397	13	74	10,128	97	69	Medium
	Tracked targets [a]	15,993	153	87	1,448	14	87	10,453	100	71	Medium
Fred Wright	Tracked targets [a]	45,071	118	60	232,958	610	108	2,837	7	92	Low
Keecha	Tracked targets CHA [a]	231,302	727	29	145,443	457	22	10,708	34	57	Medium
Kimsquit	Integration [a]	120,654	761	32	3,603	23	32	21,909	138	40	High
	Single targets	122,083	770	34	3,646	23	34	22,948	145	49	High
	Tracked targets	122,407	772	27	3,656	23	27	23,681	149	46	High
Kitlope	Integration/trawl	288,913	295	35	5,296	5	35	8,474	9	184	Low
	Single targets/trawl	289,579	296	30	5,308	5	30	10,135	10	187	Low
	Tracked targets/trawl [a]	269,217	275	28	4,935	5	28	9,125	9	173	Low

Appendix 3. Hydroacoustic estimates of pelagic fish populations (Continued).

		Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability
Lake	Analysis	N	(N/ha)	95% CI	N	(N/ha)	95% CI	N	(N/ha)	95% CI	of Estimate
Koeye	Tracked targets CHA [a]	484,180	1,063	33	9,991	22	56	26,258	58	61	Medium
Kooryet	Integration [a]	118,610	241	17	265,720	540	35	7,752	16	42	High
	Single targets	135,222	275	18	224,696	457	26	8,738	18	48	High
	Tracked targets	169,348	344	18	275,399	560	31	11,088	23	46	High
Kwinageese	Single targets	6,500	25	98	13,019	50	98	4,298	17	123	Low
	Tracked targets [a]	5,884	23	94	11,786	46	94	3,588	14	115	Low
Lonesome	Integration [a]	129,548	496	33	-	-		6,150	24	48	High
	Single targets	132,840	508	37	-	-		6,413	25	49	High
	Tracked targets	170,949	654	39	-	-		8,229	32	53	High
Meziadin	Integration [a]	9,197,825	2,613	53	9,938	3	144	1,039,277	295	69	Medium
	Single targets	10,414,610	2,959	53	9,841	3	128	1,120,918	319	70	Medium
	Tracked targets	8,897,612	2,528	53	4,829	1	117	1,116,064	317	72	Medium
Moore	Integration [a]	64,135	229	56	596,603	2,134	48	1,476	5	163	Medium
	Single targets	66,424	238	63	585,883	2,096	52	1,289	5	161	Medium
	Tracked targets	83,717	300	61	603,565	2,159	52	1,611	6	160	Medium

Appendix 3. Hydroacoustic estimates of pelagic fish populations (Continued).

Lake	Analysis	Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability of Estimate
		N	(N/ha)	95% CI	N	(N/ha)	95% CI	N	(N/ha)	95% CI	
Morice	Integration	475,798	49	44	21,379	2	44	34,131	4	74	Very low
	Single targets	620,339	64	32	27,873	3	32	32,330	3	59	Very low
	Tracked targets [a]	901,974	93	36	40,528	4	36	40,178	4	57	Very low
Namu	Tracked targets CHA [a]	177,157	548	34	25,955	80	35	27,993	87	36	Medium
Red Bluff	Integration	124,908	158	89	-	-		30,511	39	66	High
	Single targets	130,695	165	81	-	-		36,701	46	65	High
	Tracked targets [a]	131,756	166	80	-	-		36,828	46	69	High
Tankeeah (lower)	Tracked targets CHA [a]	72,270	479	39	5,205	35	41	21,243	141	45	Medium
Tankeeah (upper)	Tracked targets CHA [a]	42,569	330	37	74,379	577	37	3,345	26	116	Medium
Whalen	Tracked targets CHA [a]	158,839	74	36	-	-		215,149	101	19	Medium

[a] Prefered/Reported analysis method

CHA - tracked target anaysis with chaoborus methods employed

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa.

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
Alastair	Trawl (2mx2m)	Formalin	*O. nerka* age-0	34	34	1.74	0.18	0.52	0.61	2.76	34	54	2.2	6.2	37	64
13/09/2009		Ethanol 85%	*O. nerka* age-0	13	13	1.78	0.18	0.3	1.16	2.14	13	59	1.8	3	52	62
		Formalin	*O. nerka* age-1	42	42	4.76	0.31	1	2.21	6.61	42	76	1.6	5.2	63	86
		Ethanol 85%	*O. nerka* age-1	7	7	4.71	0.32	0.34	4.15	5.23	7	79	1.4	1.5	77	81
		Formalin	Stickleback	353	353	1.45	0.07	0.7	0.02	3.39	353	50	1	9.8	14	71
		Live	Stickleback	629	0						0					
	Swed gill net	Formalin	*O. nerka* age-0	1	1	2.17			2.17	2.17	1	58			58	58
		Formalin	*O. nerka* age-1	2	2	6	9.02	1	5.29	6.71	2	80	38.1	4.2	77	83
		Formalin	Stickleback	4	4	2.28	1.27	0.8	1.16	3.05	4	60	13.1	8.2	49	69
		Live	Stickleback	1	0						1	40			40	40
Batchellor	Beach sceine	Formalin	Cutthroat trout	19	19	3.45	2.3	4.77	0.25	13.96	19	51	13	27.1	28	100
20/07/2006		Formalin	Dolly Varden	3	3	6.36	4.76	1.92	4.5	8.33	3	79	18.8	7.5	72	87
	Minnow trap(s)	Live	Dolly Varden	5	0						5	121	28.1	22.7	92	145
	RIC gill net	Live	Cutthroat trout	56	0						56	242	10	37.5	113	325
		Live	Dolly Varden	3	0						3	152	59.6	24	125	170
	Swed gill net	Live	Dolly Varden	1	0						1	222			222	222
Bowser	Trawl (2mx2m)	Formalin	*O. nerka* age-0	12	12	1.87	0.55	0.87	0.7	3.53	12	53	5.5	8.6	38	67
04/09/2009		Ethanol 85%	*O. nerka* age-0	13	13	1.36	0.32	0.52	0.41	2.1	13	52	4.4	7.3	37	61
		Formalin	*O. nerka* age-1	14	14	4.36	0.41	0.71	3.08	5.63	14	71	2.2	3.7	64	76
		Ethanol 85%	*O. nerka* age-1	7	7	3.02	1.19	1.29	1.09	4.79	7	68	9.8	10.6	50	81
		Formalin	*O. nerka* age-2+	1	1	11.05			11.05	11.05	1	95			95	95
		Ethanol 85%	*O. nerka* age-2+	2	2	6.02	9.21	1.03	5.29	6.74	2	85	25.4	2.8	83	87
	Swed gill net	Formalin	*O. nerka* age-0	7	6	2.2	0.22	0.22	1.98	2.44	6	58	3.4	3.4	54	63
		Formalin	*O. nerka* age-1	62	62	4.69	0.29	1.13	2.33	9.16	62	74	1.4	5.4	59	90

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
		Formalin	*O. nerka* age-2+	21	21	11.14	2.19	4.81	5.5	21.25	21	96	5.6	12.2	79	124
		Formalin	Bull trout	1	1	23.49			23.49	23.49	1	121			121	121
		Live	Bull trout	3	0						3	347	138	55.6	290	401
		Formalin	Sucker	1	1	24.15			24.15	24.15	1	120			120	120
		Formalin	Coho salmon	5	5	14.37	2.74	2.21	12.57	18.09	5	103	6.2	5	98	110
		Live	sockeye[b]	2	0						2	516	50.8	5.7	512	520
Elbow 19/09/2007	Trawl (2mx2m)	Ethanol 85%	*O. nerka* age-0	11	11	5.66	1.65	2.46	2.49	11.96	11	80	6.3	9.4	64	102
		Formalin	Sculpin	5	5	0.1	0.12	0.1	0.04	0.27	5	21	7.7	6.2	15	31
		Ethanol 85%	Coho salmon	1	1	9.92			9.92	9.92	1	99			99	99
	Swed gill net	Formalin	*O. nerka* age-0	3	3	9.22	3.95	1.59	7.57	10.74	3	88	13.1	5.3	82	92
		Ethanol 85%	*O. nerka* age-0	4	4	7.34	5.94	3.73	3.8	12.59	4	86	22.1	13.9	72	105
		Ethanol 85%	*O. nerka* age-1	1	1	26.15			26.15	26.15	1	134			134	134
		Formalin	*O. nerka* age-2+	3	3	95.93	37.83	15.23	78.68	107.53	3	192	26.6	10.7	180	199
		Ethanol 85%	*O. nerka* age-2+	2	2	82.81	146.82	16.34	71.25	94.36	2	198	38.1	4.2	195	201
		Formalin	NPM[a]	3	3	139.27	45.81	18.44	123.8	159.68	3	223	32.3	13	210	236
Fred Wright 09/09/2009	Trawl (2mx2m)	Formalin	*O. nerka* age-0	2	2	3.51	11.75	1.31	2.58	4.43	2	65	63.5	7.1	60	70
		Formalin	Sculpin	2	2	0.08	0.44	0.05	0.04	0.11	2	17	31.8	3.5	14	19
	Swed gill net	Formalin	*O. nerka* age-0	2	2	7.06	10.42	1.16	6.24	7.88	2	84	50.8	5.7	80	88
		Formalin	*O. nerka* age-1	4	4	14.99	17.04	10.71	9.23	31.05	4	106	32.7	20.5	94	137
		Live	Bull trout	1	0						1	555			555	555
Keecha 04/09/2008	Trawl (2mx2m)	Formalin	*O. nerka* age-0	172	172	1.96	0.11	0.7	0.79	3.62	172	55	1	6.8	41	69
		Ethanol 85%	*O. nerka* age-0	20	20	1.89	0.25	0.53	0.81	2.63	20	59	2.3	5	48	67
		Ethanol 95%	*O. nerka* age-0	5	5	1.81	0.75	0.6	1.21	2.69	5	60	7.1	5.7	54	67

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
		Formalin	*O. nerka* age-1	4	4	5.62	1.67	1.05	4.51	7.03	4	79	7.2	4.5	74	85
		Ethanol 95%	*O. nerka* age-1	1	1	4.15			4.15	4.15	1	80			80	80
		Formalin	Stickleback	69	69	2.25	0.22	0.92	0.93	4.41	69	63	2.1	8.6	48	78
		Formalin	Prickly sculpin	1	1	1.98			1.98	1.98	1	62			62	62
		Formalin	Dolly Varden	1	1	27.78			27.78	27.78	1	140			140	140
		Live	sockeye[b]	1	0						1	380			380	380
	Swed gill net	Formalin	Stickleback	1	1	2.02			2.02	2.02	1	66			66	66
Kimsquit 12/09/2007	Trawl (2mx2m)	Formalin	*O. nerka* age-0	13	13	1.33	0.55	0.91	0.28	2.97	13	45	6.4	10.6	29	61
		Ethanol 85%	*O. nerka* age-0	20	20	1.19	0.42	0.91	0.19	2.52	20	48	6.1	13.1	31	64
		Ethanol 85%	Sculpin	1	1	0.33			0.33	0.33	1	34			34	34
	Swed gill net	Formalin	*O. nerka* age-0	9	8	4.09	0.77	0.95	2.08	5.04	8	69	4.8	5.8	56	74
		Formalin	*O. nerka* age-1	8	8	6.96	2.05	2.45	4.37	11.76	8	82	7.6	9.1	70	97
Kitlope	Trawl (2mx2m)	Formalin	*O. nerka* age-0	75	75	1.38	0.11	0.46	0.71	2.93	75	49	1.3	5.5	37	65
15/09/2007		Ethanol 85%	*O. nerka* age-0	25	25	1.1	0.13	0.32	0.64	1.93	25	51	1.9	4.6	42	61
		Formalin	*O. nerka* age-1	5	5	4.6	1.13	0.91	3.93	6.16	5	73	7.9	6.4	68	83
		Live	*O. nerka* age-1	1	0						1	90			90	90
		Ethanol 85%	*O. nerka* age-1	5	5	3.44	0.88	0.71	2.71	4.2	5	70	5.8	4.7	66	77
		Formalin	Stickleback	2	2	0.96	4.38	0.49	0.61	1.3	2	45	69.9	7.8	39	50
	Swed gill net	Formalin	*O. nerka* age-0	6	6	2.42	0.55	0.52	1.92	3.39	6	59	3.7	3.5	55	65
		Formalin	*O. nerka* age-1	17	15	5.04	0.57	1.03	4.09	7.33	17	76	2.9	5.6	71	89
		Live	*O. nerka* age-1	2	0						2	93	31.8	3.5	90	95
		Formalin	*O. nerka* age-2+	1	1	14.68			14.68	14.68	1	107			107	107
		Formalin	Stickleback	1	1	1.14			1.14	1.14	1	46			46	46
		Formalin	Coho salmon	2	2	4.94	16.01	1.78	3.68	6.2	2	71	76.2	8.5	65	77

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
Koeye 12/09/2006	Trawl (2mx2m)	Formalin	*O. nerka* age-0	36	36	1.79	0.23	0.69	0.4	3.44	36	52	2.7	7.9	33	66
		Ethanol 85%	*O. nerka* age-0	34	34	1.44	0.13	0.37	0.75	2.2	34	55	1.7	5	44	63
		Ethanol 85%	Stickleback	1	1	0.27			0.27	0.27	1	31			31	31
Kooryet 01/09/2008	Trawl (2mx2m)	Formalin	*O. nerka* age-0	35	35	2.34	0.41	1.19	0.85	7.23	35	57	2.9	8.5	42	86
		Ethanol 85%	*O. nerka* age-0	26	26	1.91	0.26	0.65	0.94	3.33	26	59	2.5	6.3	47	71
		Ethanol 95%	*O. nerka* age-0	4	4	1.72	1.14	0.72	1	2.56	4	58	11.4	7.1	50	66
		Ethanol 85%	*O. nerka* age-1	1	1	2.54			2.54	2.54	1	67			67	67
		Formalin	Stickleback	44	44	3.53	0.26	0.87	0.64	4.55	44	73	2.5	8.3	39	81
	Swed gill net	Formalin	Stickleback	1	1	4.07			4.07	4.07	1	77			77	77
Kwinageese 07/09/2009	Trawl (2mx2m)	Formalin	*O. nerka* age-0	1	1	0.72			0.72	0.72	1	38			38	38
		Formalin	*O. nerka* age-1	1	1	14.11			14.11	14.11	1	101			101	101
		Formalin	Coho salmon	4	4	0.36	0.4	0.25	0.11	0.65	4	31	10.2	6.4	24	38
	Swed gill net	Formalin	*O. nerka* age-2+	1	1	29.13			29.13	29.13	1	130			130	130
		Formalin	Redside shiner	62	55	7.15	0.44	1.65	3.28	11.06	55	78	1.5	5.7	61	90
		Live	Redside shiner	1	0						1	80			80	80
		Formalin	Rainbow trout	1	1	27.05			27.05	27.05	1	129			129	129
		Formalin	Lake chub	5	5	18.52	7.99	6.43	7.86	24.77	5	115	19.5	15.7	88	128
Lonesome 08/09/2007	Trawl (2mx2m)	Formalin	*O. nerka* age-0	34	34	1.89	0.24	0.7	1.06	3.95	34	54	2.1	6	45	70
		Ethanol 85%	*O. nerka* age-0	29	29	1.83	0.42	1.09	0.85	6.06	29	58	3.2	8.4	48	87
		Ethanol 85%	*O. nerka* age-1	3	3	10.04	5.92	2.39	7.65	12.42	3	101	19.9	8	93	109
		Formalin	Sculpin	2	2	0.31	1.52	0.17	0.19	0.43	2	31	57.2	6.4	26	35
		Ethanol 85%	Sculpin	1	1	0.16			0.16	0.16	1	27			27	27
		Formalin	Prickly sculpin	3	3	4.25	5.96	2.4	1.93	6.72	3	66	28.6	11.5	54	77

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
	Dip net	Formalin	NPM[a]	1	1	96.33			96.33	96.33	1	193			193	193
		Formalin	Prickly sculpin	1	1	41.42			41.42	41.42	1	135			135	135
	Swed gill net	Formalin	*O. nerka* age-0	4	3	2.93	1.76	0.96	2.18	4.01	3	62	11.1	6	56	68
		Ethanol 85%	*O. nerka* age-0	7	6	3.19	0.22	0.22	2.93	3.43	6	70	2.1	2.1	67	73
		Formalin	*O. nerka* age-1	1	1	25.63			25.63	25.63	1	127			127	127
		Formalin	*O. nerka* age-2+	2	2	203.56	1001.3	111.45	124.75	282.36	2	238	565.4	62.9	193	282
		Live	*O. nerka* age-2+	1	0						1	212			212	212
		Live	Rainbow trout	1	0						1	331			331	331
		Live	Cutthroat trout	1	0						1	265			265	265
Meziadin 17/09/2009	Trawl (3mx7m)	Formalin	*O. nerka* age-0	382	381	1.84	0.09	0.87	0.28	7.85	381	54	0.8	8.4	30	88
		Live	*O. nerka* age-0	259	0						0					
		Ethanol 85%	*O. nerka* age-0	60	60	1.73	0.15	0.58	0.46	2.9	60	57	1.7	6.6	39	68
		Formalin	*O. nerka* age-1	99	99	9.53	0.5	2.5	4.3	20.36	99	94	1.5	7.6	73	121
		Live	*O. nerka* age-1	205	0						0					
		Ethanol 85%	*O. nerka* age-1	36	36	8.69	0.87	2.57	3.63	15.56	36	96	3.2	9.5	72	115
		Formalin	Whitefish	1	1	22.5			22.5	22.5	1	125			125	125
Moore 07/09/2008	Trawl (2mx2m)	Formalin	*O. nerka* age-0	62	62	2.75	0.11	0.43	1.46	3.37	62	62	0.9	3.4	50	67
		Ethanol 85%	*O. nerka* age-0	20	20	2.32	0.22	0.48	1.07	2.97	20	63	2.2	4.7	49	68
		Ethanol 95%	*O. nerka* age-0	3	3	2.26	0.55	0.22	2.07	2.5	3	64	4.3	1.7	63	66
		Formalin	Stickleback	231	231	0.77	0.09	0.7	0.06	2.48	231	38	1.8	14	18	63
		Ethanol 85%	Stickleback	5	5	1.1	0.79	0.63	0.07	1.61	5	47	19	15.3	20	57
	Swed gill net	Formalin	Stickleback	20	20	1.4	0.16	0.34	0.9	2.5	20	52	1.6	3.3	48	62

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
Morice	Trawl (3mx7m)	Formalin	*O. nerka* age-0	20	20	4.12	0.94	2	1.04	7.58	20	70	5.5	11.8	46	87
22/09/2009		Formalin	*O. nerka* age-1	2	2	13.06	7.24	0.81	12.49	13.63	2	102	38.1	4.2	99	105
		Formalin	Whitefish	1	1	6.47			6.47	6.47	1	89			89	89
Namu	Trawl (2mx2m)	Formalin	*O. nerka* age-0	21	21	2.12	0.35	0.77	0.57	3.66	21	54	3.4	7.4	35	66
15/09/2006		Ethanol 85%	*O. nerka* age-0	20	20	1.9	0.44	0.93	0.53	3.63	20	57	4.2	8.9	41	71
		Formalin	Stickleback	6	6	4.45	2.19	2.08	1.48	6.19	6	76	13.6	12.9	57	89
	Swed gill net	Formalin	O. nerka age-0	2	1	2.34			2.34	2.34	1	59			59	59
Red Bluff	Trawl (2mx2m)	Ethanol 85%	*O. nerka* age-0	16	16	0.4	0.12	0.23	0.13	0.99	16	38	4	7.5	28	53
23/07/2006		Ethanol 85%	*O. nerka* age-1	1	1	7			7	7	1	93			93	93
		Ethanol 85%	Larval fish	10	0						10	10	1	1.4	7	12
	Dip net	Formalin	Sculpin	1	1	1.48			1.48	1.48	1	53			53	53
	Beach sceine	Formalin	Stickleback	28	28	0.71	0.15	0.38	0.23	1.53	28	41	2.7	7.1	29	52
		Live	Stickleback	31	0						0					
		Formalin	Sculpin	6	6	0.23	0.07	0.07	0.15	0.34	6	28	3.2	3.1	23	32
	Minnow trap(s)	Live	Stickleback	122	0						122	49	0.8	4.4	39	59
		Formalin	Sculpin	3	3	1.36	0.5	0.2	1.2	1.59	3	52	10.3	4.2	49	57
		Live	Sculpin	1	0						1	60			60	60
		Live	Cutthroat trout	1	0						1	350			350	350
	RIC gill net	Live	Cutthroat trout	26	0						25	352	17.3	42.1	190	410
	Swed gill net	Ethanol 85%	*O. nerka* age-1	5	5	11.14	4.59	3.7	6.23	16.32	5	105	11.6	9.3	91	115
		Ethanol 85%	*O. nerka* age-2+	2	2	57.62	3.37	0.37	57.35	57.88	2	173	31.8	3.5	170	175
		Live	Cutthroat trout	3	0						3	476	81.8	32.9	438	496

Appendix 4. Summary of captured fish for each survey by capture gear, preservative, and taxa (Continued).

			Catch		Weight (gm)						Fork length (mm)					
Lake/Date	Gear	Fish State	Taxa	n	n	mean	95CI	SD	min	max	n	mean	95CI	SD	min	max
Tankeeah (lower)	Trawl (2mx2m)	Formalin	*O. nerka* age-0	10	10	2.35	0.63	0.89	1.41	4.32	10	57	4.6	6.5	50	71
18/09/2006		Ethanol 85%	*O. nerka* age-0	19	19	2.64	0.42	0.86	0.81	4.23	19	65	3.5	7.3	44	77
		Formalin	Stickleback	1	1	0.37			0.37	0.37	1	34			34	34
		Ethanol 85%	Stickleback	1	1	0.2			0.2	0.2	1	29			29	29
	Swed gill net	Formalin	O. nerka age-0	1	1	6.34			6.34	6.34	1	80			80	80
		Formalin	Stickleback	1	1	1.55			1.55	1.55	1	51			51	51
		Formalin	Coho salmon	1	1	8.64			8.64	8.64	1	82			82	82
Tankeeah (upper) 19/09/2006	Trawl (2mx2m)	Ethanol 85%	*O. nerka* age-0	4	4	1.94	0.52	0.32	1.54	2.33	4	60	4.5	2.8	56	62
		Formalin	Stickleback	7	7	1.62	0.23	0.25	1.2	1.88	7	55	1.6	1.7	52	57
Whalen	Trawl (2mx2m)	Ethanol 85%	*O. nerka* age-1	1	1	3.41			3.41	3.41	1	74			74	74
26/07/2006	Minnow trap(s)	Live	Dolly Varden	9	0						9	111	9.7	12.7	94	131
	RIC gill net	Ethanol 85%	*O. nerka* age-1	8	8	9.34	1.37	1.64	6.69	11.74	8	100	5.6	6.7	89	112
		Live	Coho salmon	1	1	42.11			42.11	42.11	1	141			141	141
		Live	Dolly Varden	19	9	39.4	23.92	34.15	16.02	117.47	19	189	47.8	99.1	96	494
	Swed gill net	Ethanol 85%	*O. nerka* age-1	1	1	13.25			13.25	13.25	1	116			116	116

[a] NPM = Northern pikeminnow

[b] sockeye = adult/jack sockeye

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Clear											
Alastair	14-Sep-09	*O. nerka*, age-0	2	41	0.85	25	*Diacyclops*	35.3	0.11199	17.6	16.3
							Eubosmina	164.0	0.17703	81.5	25.8
							Insect	2.0	0.39655	1.0	57.8
Alastair	14-Sep-09	*O. nerka*, age-1	3	78	5.2	5	*Diacyclops*	10.0	0.02199	22.4	1.7
							Eubosmina	28.3	0.03079	63.4	2.4
							Insect	6.3	1.25554	14.2	96.0
Alastair	14-Sep-09	Stickleback	50	48	1.27	23	*Diacyclops*	83.2	0.17584	47.4	55.3
							Daphnia	1.9	0.01707	1.1	5.4
							Eubosmina	90.3	0.1053	51.4	33.1
							Insect	0.1	0.01983	0.1	6.2
Alastair	14-Sep-09	*O. nerka*, mix of age-0 & 1	22	69	3.47	2	*Diacyclops*	11.6	0.02208	26.2	6.5
							Eubosmina	31.3	0.03623	70.6	10.7
							Insect	1.4	0.27937	3.2	82.7
Azuklotz	27-Aug-03	*O. nerka*, age-0	13	72	4.77	86	*Diacyclops*	76.2	0.13248	4	1.2
							Daphnia	1840	11.2207	95.5	98.3
							Bosmina	11.5	0.057	0.6	0.5
Bear	28-Aug-03	*O. nerka*, age-0	3	49	1.57	63	*Diacyclops*	37	0.09836	25.2	0.8
							Daphnia	49	0.57435	33.3	4.6
							Bosmina	2	0.00818	1.4	0.1
							Heterocope	5.5	0.51079	3.7	4.1
							Insect	46	11.1118	31.3	89.4

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Leptodora	7.5	0.12488	5.1	1
Bear	26-Aug-03	Redside shiner	10	84	8.19	23	*Chironomid*	0.8	0.21576	6.2	6.9
							Insect	12.1	2.92289	93.8	93.1
Bear	28-Aug-03	Pygmy whitefish	10	62	3.31	30	*Chironomid*	10.4	0.60495	77	46.6
							Daphnia	0.1	0.00103	0.7	0.1
							Heterocope	0.1	0.0129	0.7	1
							Insect	2.8	0.67651	20.7	52.2
							Leptodora	0.1	0.00167	0.7	0.1
Elbow	20-Sep-07	*O. nerka*, age-0	10	78	5.03	58	*Diacyclops*	2.3	0.00517	0.1	0.04
							Daphnia	1569.4	14.0493	99.0	97.9
							Eubosmina	9.9	0.0347	0.6	0.2
							Insect	4.3	0.25993	0.3	1.8
Fred Wright	10-Sep-09	*O. nerka*, age-0	2	65	3.51	90	*Diacyclops*	30.8	0.08564	2.7	0.8
							Daphnia	1026.9	8.65654	90.8	77.3
							Holopedium	26.9	0.09655	2.4	0.9
							Insect	11.5	2.28768	1.0	20.4
							Polyphemus	34.6	0.07607	3.1	0.7
Johanson	12-Sep-04	*O. nerka*, age-0	30	49	1.34	22	*Alona*	1.4	0.00126	0.8	0.5
							Bosmina	144.1	0.20089	84.9	71.3
							Diacyclops	21.3	0.03617	12.5	12.8

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

Water Type Lake	Date	Fish Taxa	Fish N (#)	Fish Mean Length (mm)	Fish Mean Weight (g)	Fish Mean Fullness (%)	Diet Items	Mean Diet Items per Fish N (#)	Mean Diet Items per Fish Weight (mg)	Mean Diet Items per Fish N (%)	Mean Diet Items per Fish Weight (%)
							Holopedium	3	0.00977	1.7	3.5
							Insect	0.1	0.03355	0.1	11.9
Johnston	01-Sep-05	*O. nerka*, age-0	23	38	0.63	7	*Cyclopod*	11	0.04397	75.8	55.1
							Bosmina	3.4	0.00436	23.4	5.5
							Insect	0.1	0.0315	0.9	39.5
Kimsquit	13-Sep-07	*O. nerka*, age-0	23	46	1.28	28	*Diacyclops*	22.0	0.06234	11.4	4.1
							Eubosmina	1.8	0.00264	0.9	0.2
							Holopedium	165.8	0.6911	86.0	45.6
							Insect	3.3	0.75892	1.7	50.1
Kitlope	16-Sep-07	*O. nerka*, mix of age-0 & 1	20	55	2.04	25	*Alona*	0.1	0.00002	0.2	0.001
							Chaoborus larvae	0.1	0.01294	0.1	0.8
							Chironomid	0.2	0.07657	0.3	4.8
							Diacyclops	1.0	0.00303	1.5	0.2
							Daphnia	1.9	0.01418	2.9	0.9
							Eubosmina	58.7	0.16213	86.5	10.1
							Insect	5.8	1.33967	8.5	83.3
Kitwanga	01-Sep-03	*O. nerka*, age-0	10	49	1.54	54	*Chaoborus*	14	1.90525	9.6	52
							Diaphanosoma	7	0.01468	4.8	0.4
							Daphnia	97.5	1.20571	66.8	32.9

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Leptodiaptomus	25.5	0.50398	17.5	13.8
							Leptodora	2	0.0333	1.4	0.9
Kwinageese	07-Sep-09	Redside shiner	10	78	7.62	0	none	0.0	0.0		
Kwinageese	07-Sep-09	Lake chub	4	122	21.19	3	*Diacyclops*	1.0	0.00303	2.5	0.6
							Daphnia	2.3	0.01099	5.5	2.1
							Eubosmina	32.3	0.10035	79.1	19.2
							Holopedium	3.3	0.01165	8.0	2.2
							Insect	2.0	0.39653	4.9	75.9
Lakelse	14-Jul-03	*O. nerka*, age-0	16	56	1.7	35	*Ceratopognid*	0.4	0.05026	0.2	3.5
							Daphnia	152.8	1.3599	98.2	94.1
							Epischura	2.5	0.03471	1.6	2.4
Lakelse	25-Sep-04	*O. nerka*, age-0	20	70	4.38	29	*Chironomid*	0.6	0.34872	0.2	10.3
							Diacyclops	21.3	0.05234	7	1.5
							Diaphanosoma	21.5	0.08035	7	2.4
							Daphnia	43.8	0.41243	14.3	12.2
							Epischura	215.6	2.26294	70.7	66.7
							Insect	2.3	0.23685	0.8	7
Lakelse	05-Sep-05	*O. nerka*, age-0	20	64	3.81	39	*Diacyclops*	4.2	0.01014	1.4	0.0
							Daphnia	286.2	2.761285	97.3	3.4
							Epischura	1	0.01221	0.3	0.0

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

Water Type			Fish					Mean Diet Items per Fish			
Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Bosmina	2	0.00925	0.7	0.0
							Neomysis	0.75	0.653502	0.3	0.8
Lonesome	11-Sep-07	*O. nerka*, age-0	20	56	1.99	52	*Diacyclops*	3.8	0.00911	0.9	0.2
							Daphnia	427.5	5.2775	96.9	98.8
							Diaptomus	4.6	0.03065	1.0	0.6
							Eubosmina	5.2	0.02433	1.2	0.5
McDonnel	13-Sep-02	*O. nerka*, age-0	10	50	1.35	42	*Acanthocyclops*	10.5	0.02011	2.3	0.6
							Daphnia	417	2.63841	89.7	83
							Bosmina	3	0.00528	0.7	0.2
							Leptodiaptomus	34.5	0.51409	7.4	16.2
Meziadin	17-Sep-09	*O. nerka*, age-0	20	59	2.37	35	*Diacyclops*	133.4	0.49944	29.3	17.1
							Daphnia	306.6	1.8933	67.4	64.6
							Diaptomus	3.8	0.02055	0.8	0.7
							Eubosmina	8.8	0.01976	1.9	0.7
							Insect	2.5	0.49566	0.5	16.9
Meziadin	17-Sep-09	*O. nerka*, age-1	40	96	10.43	23	*Diacyclops*	241.9	0.89366	54.2	33.2
							Daphnia	179.6	1.03636	40.2	38.5
							Diaptomus	2.9	0.01302	0.7	0.5
							Eubosmina	18.3	0.04224	4.1	1.6
							Insect	3.6	0.7081	0.8	26.3

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Meziadin	17-Sep-09	*O. nerka*, mix of age-0 & 1	20	61	2.77	30	*Diacyclops*	137.7	0.44217	50.3	45.0
							Daphnia	15.5	0.10265	5.6	10.4
							Diaptomus	0.5	0.00282	0.2	0.3
							Eubosmina	119.1	0.25489	43.5	25.9
							Insect	0.9	0.18024	0.3	18.3
Morice (Atna Bay)	15-Sep-02	*O. nerka*, age-0	10	57	2.13	44	*Diacyclops*	27.3	0.06772	17.5	2.3
							Daphnia	2.1	0.01073	1.4	0.4
							Bosmina	55.7	0.28078	35.6	9.7
							Holopedium	64.3	0.85606	41.1	29.5
							Insect	7	1.68226	4.5	58.1
Morice (main lake)	16-Sep-02	*O. nerka*, age-0	3	45	0.83	42	*Diacyclops*	3.7	0.00962	11.1	1.8
							Bosmina	3	0.01814	9.1	3.4
							Holopedium	26	0.41933	78.8	79.5
							Insect	0.3	0.08051	1	15.3
Morice (Atna Bay)	23-Sep-09	*O. nerka*, age-0	10	73	4.6	35	*Diacyclops*	343.3	1.08819	70.1	65.8
							Daphnia	3.3	0.03484	0.7	2.1
							Eubosmina	113.3	0.4243	23.1	25.6
							Holopedium	30.0	0.10758	6.1	6.5
Morice (Atna Bay)	23-Sep-09	*O. nerka*, mix of age-0 & 1	6	84	7.77	48	*Diacyclops*	408.3	1.29416	65.1	50.0
							Daphnia	18.8	0.19598	3.0	7.6
							Eubosmina	168.8	0.6594	26.9	25.5
							Holopedium	29.2	0.02639	4.7	1.0

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Insect	2.1	0.41304	0.3	16.0
Slamgeesh	07-Sep-01	*O. nerka*, age-0	20	66	3.95	82	*Acanthocyclops*	12.3	0.01873	0.9	0.1
							Daphnia	1023	9.41261	75.5	56.1
							Bosmina	14	0.04768	1	0.3
							Insect	4.7	1.12728	0.3	6.7
							Leptodiaptomus	301	6.16614	22.2	36.8
Stephens	10-Sep-02	*O. nerka*, age-0	10	57	2	46	*Diacyclops*	6	0.01759	3.8	0.5
							Daphnia	4.9	0.02937	3.1	0.8
							Bosmina	9.3	0.02976	5.9	0.8
							Heterocope	19.1	1.46054	12.1	40.1
							Insect	7.1	1.71303	4.5	47.1
							Leptodiaptomus	111.8	0.39017	70.7	10.7
Sustut	10-Sep-04	*O. nerka*, age-0	30	50	1.45	9	*Alona*	0.7	0.0186	0.4	3.2
							Amphipod	0.3	0.40742	0.2	69.7
							Bosmina	170.9	0.15454	99.1	26.4
							Diacyclops	0.7	0.0044	0.4	0.8
Swan	06-Sep-02	*O. nerka*, age-0	7	47	1.1	28	*Diacyclops*	18.3	0.0702	21.6	8
							Daphnia	39.4	0.35538	46.6	40.4
							Bosmina	4.6	0.02215	5.4	2.5
							Heterocope	6.3	0.33812	7.4	38.4

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Swan	07-Sep-02	*O. nerka*, age-1	10	70	3.53	18	*Holopedium*	0.6	0.00593	0.7	0.7
							Leptodiaptomus	15.4	0.08833	18.2	10
							Diacyclops	9.8	0.03298	8.8	4.4
							Daphnia	27.8	0.20065	25.1	26.8
							Bosmina	63	0.28093	57	37.5
							Heterocope	1.5	0.19353	1.4	25.8
							Leptodiaptomus	7.9	0.02871	7.1	3.8
							Leptodora	0.8	0.01249	0.7	1.7
Stained											
Banks East	18-Sep-04	*O. nerka*, age-0	12	65	3.3	50	*Diacyclops*	0.9	0.00279	0.1	0.1
							Diaptomous	1.8	0.0059	0.2	0.2
							Epischura	88.4	0.87078	7.6	29.7
							Bosmina	1075	2.02099	91.9	68.9
							Holopedium	3.1	0.03245	0.3	1.1
Banks East	18-Sep-04	Stickleback	10	71	3.77	6	Amphipod	0.1	0.02739	1.9	67.4
							Diacyclops	0.1	0.00012	1.9	0.3
							Daphnia	0.1	0.00044	1.9	1.1
							Diaptomous	0.2	0.00097	3.9	2.4
							Epischura	0.2	0.00244	3.9	6
							Bosmina	4.5	0.00926	86.5	22.8

Appendix 5. Stomach contents of fish caught during surveys of the study iakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Banks West	17-Sep-04	*O. nerka*, age-0	20	65	3.27	48	*Diacyclops*	1.3	0.00391	0.1	0.1
							Daphnia	43.8	0.43626	2.6	9.5
							Diaptomous	7.5	0.02673	0.5	0.6
							Epischura	28.8	0.29349	1.7	6.4
							Bosmina	1577.5	3.78786	94.7	82.5
							Holopedium	3.8	0.03894	0.2	0.9
							Polyphemus	3.8	0.00515	0.2	0.1
Banks West	17-Sep-04	Stickleback	15	65	3.33	36	*Ceriodaphnia*	9.3	0.03725	1.1	0.8
							Diacyclops	3.3	0.00684	0.4	0.1
							Daphnia	342.3	3.34741	39	68.4
							Diaptomous	2.7	0.01297	0.3	0.3
							Epischura	14.3	0.12645	1.6	2.6
							Bosmina	500	1.34174	56.9	27.4
							Holopedium	1.3	0.01385	0.2	0.3
							Polyphemus	5.3	0.00806	0.6	0.2
Ecstall	25-Aug-05	*O. nerka*, age-0	3	43	1.11	25	*Alona*	0.3	0.00295	5	1.1
							Cyclopod	4.3	0.0212	65	8
							Bosmina	1	0.00101	15	0.4
							Insect	1	0.24154	15	90.6
Ecstall	25-Aug-05	Stickleback	20	53	1.48	12	*Alona*	0.1	0.00004	0.8	0
							Chironomid	3.1	2.0165	25.6	95.6
							Cyclopod	0.1	0.00028	0.8	0

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Diacyclops	0.5	0.00134	3.8	0.1
							Bosmina	7.9	0.00767	66	0.4
							Insect	0.4	0.08455	2.9	4
Evelyn	04-Sep-01	*O. nerka*, age-0	10	43	1.04	55	*Acanthocyclops*	0.6	0.00116	0.3	0.1
							Bosmina	10.2	0.01829	5.8	0.9
							Chironomid	1.2	0.87515	0.7	44.2
							Daphnia	132.6	0.77914	75.4	39.4
							Holopedium	0.6	0.00623	0.3	0.3
							Insect	0.6	0.14494	0.3	7.3
							Leptodiaptomus	19.8	0.13321	11.3	6.7
							Schapholoberis	10.2	0.02063	5.8	1
Evelyn	04-Sep-01	*O. nerka*, age-1	10	78	6.53	45	*Acanthocyclops*	5.6	0.01086	1	0.2
							Bosmina	13.1	0.02277	2.4	0.4
							Chironomid	11.3	1.71948	2.1	33.4
							Daphnia	453.8	2.22477	83.5	43.2
							Insect	3.8	0.90585	0.7	17.6
							Leptodiaptomus	35.6	0.22405	6.6	4.4
							Polyphemus	9.4	0.02291	1.7	0.5
							Schapholoberis	11.3	0.01564	2.1	0.3
Evelyn	04-Sep-01	Stickleback	8	97	11.59	4	*Acanthocyclops*	0.8	0.00145	0.7	0.1
							Bosmina	3	0.00497	2.7	0.4
							Chaoborus	0.8	0.11624	0.7	9.6

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

Water Type			Fish					Mean Diet Items per Fish			
Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Chironomid	0.8	0.3624	0.7	30
							Daphnia	98.3	0.69495	89.7	57.4
							Holopedium	0.8	0.00779	0.7	0.6
							Leptodiaptomus	3	0.01352	2.7	1.1
							Polyphemus	0.8	0.00221	0.7	0.2
							Schapholoberis	1.5	0.00637	1.4	0.5
Hartley Bay (Lower)	30-Aug-05	Stickleback	17	56	2.03	15	*Acari*	3.9	0.00799	45	1.4
							Chaoborus	2.9	0.45534	32.9	79.8
							Chironomid	0.2	0.00471	2	0.8
							Diaptomous	0.1	0.00018	0.7	0
							Bosmina	1.1	0.00155	12.1	0.3
							Insect	0.7	0.101	7.4	17.7
Keecha	04-Sep-08	*O. nerka*, age-0	40	55	2	59	*Diacyclops*	0.3	0.00088	0.1	0.1
							Daphnia	0.7	0.00822	0.3	0.6
							Diaptomus	46.4	0.31462	19.4	21.6
							Epischura	18.0	0.09944	7.6	6.8
							Eubosmina	164.8	0.18936	69.0	13.0
							Insect	4.0	0.79655	1.7	54.6
							Leptodora	4.7	0.05016	2.0	3.4
Keecha	04-Sep-08	Stickleback	28	65	2.57	31	*Ceratopognid*	0.04	0.00708	0.1	0.9
							Daphnia	0.1	0.00085	0.2	0.1
							Diaptomus	19.9	0.08796	41.0	11.3

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Epischura	3.9	0.02712	7.9	3.5
							Eubosmina	21.0	0.02874	43.2	3.7
							Insect	3.1	0.61711	6.4	79.4
							Leptodora	0.5	0.00516	1.0	0.7
							worm	0.04	0.00331	0.1	0.4
Keecha	04-Sep-08	*O. nerka*, mix of age-0 & 1	10	62	2.78	60	*Diaptomus*	33.6	0.22833	12.6	35.1
							Epischura	10.9	0.06398	4.1	9.8
							Eubosmina	210.9	0.23187	78.9	35.6
							Leptodora	11.8	0.12659	4.4	19.5
Kitkiata	27-Aug-05	*O. nerka*, age-0	20	43	1	8	*Chironomid*	0.1	0.00764	0.2	2.1
							Diacyclops	0.3	0.00076	1.1	0.2
							Bosmina	20.9	0.01736	92.3	4.7
							Insect	1.4	0.34758	6.4	93.1
Kitkiata	27-Aug-05	Stickleback	20	49	1.2	13	*Chironomid*	0.1	0.02642	0.5	2.6
							Chydorus	0.1	0.00007	0.5	0
							Bosmina	6.3	0.00916	60	0.9
							Insect	4.1	0.9904	39.1	96.5
Koeye	12-Sep-06	*O. nerka*, age-0	20	56	1.56	50	*Bosmina*	83.7	0.20123	11.7	4.7
							Chaoborus larvae	2.5	0.46558	0.3	11.0
							Chironomid	0.6	0.08742	0.1	2.1
							Diacyclops	32.5	0.11724	4.5	2.8
							Daphnia	576.5	3.31575	80.7	78.1

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Diaptomus	1.9	0.01194	0.3	0.3
							Polyphemus	15.6	0.03716	2.2	0.9
							Schapholoberis	1.7	0.01051	0.2	0.2
Kooryet	02-Sep-08	*O. nerka*, age-0	37	59	2.27	49	*Daphnia*	0.9	0.00646	0.1	0.1
							Diaptomus	681.1	3.34798	62.4	54.8
							Epischura	210.8	1.37864	19.3	22.6
							Eubosmina	192.8	0.30733	17.7	5.0
							Insect	5.4	1.06896	0.5	17.5
Kooryet	02-Sep-08	Stickleback	20	75	3.8	25	*Diaptomus*	61.7	0.29293	8.2	16.4
							Epischura	22.5	0.15516	3.0	8.7
							Eubosmina	665.0	1.34297	88.8	75.0
Moore	08-Sep-08	*O. nerka*, age-0	40	63	2.7	48	*Alona*	0.1	0.00005	0.1	0.001
							Diaptomus	1.9	0.01222	2.6	0.3
							Eubosmina	38.5	0.03903	54.5	0.9
							Holopedium	8.2	0.02389	11.6	0.5
							Insect	22.0	4.3491	31.1	98.3
Moore	08-Sep-08	Stickleback	33	48	1.31	30	*Alona*	0.1	0.00004	0.1	0.002
							Daphnia	0.1	0.00129	0.1	0.1
							Diaptomus	1.5	0.0095	1.8	0.6
							Eubosmina	61.5	0.06092	75.1	3.8
							Holopedium	11.1	0.03229	13.5	2.0
							Insect	7.7	1.51514	9.4	93.6

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Namu	15-Sep-06	*O. nerka*, age-0	20	55	2.2	44	*Bosmina*	26.7	0.04635	26.3	7.7
							Chaoborus larvae	0.4	0.06207	0.4	10.3
							Chironomid	0.4	0.05683	0.4	9.5
							Diacyclops	32.0	0.0669	31.5	11.1
							Daphnia	33.8	0.33887	33.3	56.4
							Diaptomus	5.0	0.02239	4.9	3.7
							Holopedium	1.1	0.00438	1.0	0.7
							Polyphemus	1.8	0.00156	1.7	0.3
							Schapholoberis	0.5	0.00105	0.5	0.2
Namu	15-Sep-06	Stickleback	6	76	4.45	10	*Bosmina*	75.5	0.13852	48.6	17.8
							Chaoborus larvae	1.5	0.31931	1.0	41.1
							Diacyclops	1.0	0.00315	0.6	0.4
							Diaphanosoma	3.5	0.0166	2.3	2.1
							Daphnia	67.0	0.2851	43.1	36.7
							Holopedium	7.0	0.01437	4.5	1.8
Red Bluff	24-Jul-06	*O. nerka*, age-0	13	39	0.42	22	*Acanthocyclops*	6.5	0.01564	10.5	4.1
							Bosmina	2.9	0.01013	4.8	2.6
							Chironomid	0.1	0.01166	0.1	3.0
							Daphnia	3.5	0.02395	5.8	6.2
							Diaptomus	46.2	0.31417	75.3	81.7
							Holopedium	2.2	0.00898	3.5	2.3

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Red Bluff	24-Jul-06	*O. nerka*, age-1	3	56	2.6	37	*Acanthocyclops*	19.2	0.01862	3.4	0.6
							Bosmina	211.5	0.64306	37.8	21.8
							Daphnia	19.2	0.20771	3.4	7.0
							Diaptomus	198.1	1.62935	35.4	55.2
							Holopedium	88.5	0.36878	15.8	12.5
							Polyphemus	5.8	0.01399	1.0	0.5
							Schapholoberis	17.3	0.06888	3.1	2.3
Red Bluff	24-Jul-06	Stickleback	20	43	0.86	22	*Acanthocyclops*	20.3	0.04025	40.9	5.9
							Alona	5.5	0.00227	11.1	0.3
							Bosmina	1.3	0.00558	2.6	0.8
							Chironomid	1.2	0.14005	2.4	20.5
							Chydorus	17.1	0.01594	34.6	2.3
							Ceratopognid	0.9	0.19045	1.7	27.8
							Diacyclops	0.1	0.00043	0.2	0.1
							Diaptomus	0.9	0.00308	1.8	0.5
							unidentified egg	1.0		2.0	
							Insect	0.8	0.16597	1.5	24.2
							Nauplii	0.2	0.00007	0.3	0.01
							worm	0.4	0.12075	0.8	17.6
Tankeeah (lower)	18-Sep-06	O. nerka, age-0	20	62	2.75	39	*Acanthocyclops*	4.3	0.00598	1.4	1.1
							Alona	0.3	0.00054	0.1	0.1
							Bosmina	232.0	0.32135	78.3	56.5

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
							Chaoborus larvae	0.8	0.12414	0.3	21.8
							Diacyclops	0.8	0.00183	0.3	0.3
							Diaphanosoma	5.3	0.0047	1.8	0.8
							Daphnia	0.3	0.0025	0.1	0.4
							Diaptomus	7.5	0.03447	2.5	6.1
							Holopedium	45.3	0.0735	15.3	12.9
Tankeeah (upper)	19-Sep-06	O. nerka, age-0	3	59	1.92	50	*Acanthocyclops*	35.0	0.05311	4.8	2.2
							Bosmina	377.5	0.48273	51.5	19.8
							Diaphanosoma	10.0	0.00751	1.4	0.3
							Daphnia	2.5	0.02504	0.3	1.0
							Diaptomus	287.5	1.8312	39.2	75.3
							Holopedium	17.5	0.03024	2.4	1.2
							Polyphemus	2.5	0.00215	0.3	0.1
Tankeeah (upper)	19-Sep-06	Stickleback	6	55	1.58	15	*Acanthocyclops*	1.8	0.00265	17.2	3.3
							Bosmina	4.7	0.00772	43.8	9.7
							Chaoborus larvae	0.2	0.02759	1.6	34.8
							Chironomid	0.2	0.02526	1.6	31.8
							Diaptoms	3.7	0.01546	34.4	19.5
							Holopedium	0.2	0.00069	1.6	0.9

Appendix 5. Stomach contents of fish caught during surveys of the study lakes and from surveys in Hume and MacLellan (2008) (Continued).

			Fish					Mean Diet Items per Fish			
Water Type Lake	Date	Fish Taxa	N (#)	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)	Diet Items	N (#)	Weight (mg)	N (%)	Weight (%)
Glacially Turbid											
Bowser	07-Sep-09	*O. nerka*, age-0	2	51	1.51	50	*Diacyclops*	2.5	0.00715	7.2	0.1
							Insect	32.0	6.34442	92.8	99.9
Bowser	07-Sep-09	*O. nerka*, mix of age-0 & 1	36	64	3.24	53	*Diacyclops*	217.9	0.84506	93.8	22.7
							Insect	14.5	2.87606	6.2	77.3
Kitsumkalum	05-Sep-05	*O. nerka*, age-0	6	63	2.33	22	*Chaoborus*	0.3	0.04613	0.3	1.1
							Cyclopod	2.1	0.00651	2.4	0.2
							Daphnia	1.2	0.00959	1.4	0.2
							Diaptomous	67.3	0.33624	77.4	7.9
							Insect	16.1	3.88199	18.5	90.7
Motase	30-Aug-03	*O. nerka*, age-0	5	44	1.1	10	*Chironomid*	0.4	0.02526	1.8	2.2
							Diacyclops	16.4	0.06323	73.2	5.6
							Insect	5.6	1.03684	25	92.1
Motase	30-Aug-03	*O. nerka*, age-1	5	70	4.38	37	*Diacyclops*	0.2	0.00122	0.6	0
							Insect	31.6	7.63334	99.4	100

Appendix 6. Late summer zooplankton densities and biomass estimated from 160 um mesh, vertical haul, Wisconsin net samples. Haul depth was 30 m, except where indicated.

Lake	**stn**	**Date (yymmdd)**	***Daphniidae***	***Bosminidae***	***Holopedium***	**Other Cladocera**	***Cyclopoida***	***Calanoida***	**Macro inverteb.**	**Nauplii**	**Other**	**Total**
						biomass (mg/m^2)						
Alastair	1	2009-09-15	86	350	0.4	0.2	131					569
Batchellor	1	2006-08-22	444	20	48	1	9	117		2		641
Bowser	2	2009-09-04	0.1	< 0.1			14	0.1				14
Elbow	1	2007-08-29	1,408	23			455			0.2		1,887
Fred Wright[c]	1	2009-09-10	488	130	110	4	272	4	6	0.2		1,014
Keecha[c]	1	2004-08-30		33		10	5	64	22	0.2		134
Kimsquit	1	2007-08-27		63	228		200					491
Kitlope	1	2007-08-27	4	3			13			0.1		20
Koeye[c]	1	2006-09-01	314	92	19	4	86	102	79	1	< 0.1	696
Kooryet	1	2004-08-30		37		2		105		0.1		144
Kwinageese	1	2009-09-08	27	240	202		738	607				1,814
Lonesome	2	2007-08-26	1,341	24			140	57		0.3		1,564
Meziadin[b]		2009-09-17	638	17			429	59				1,142
Moore	1	2004-08-28	0.2	30	1	1	5	21		0.2		57
Morice	4	2009-09-21	13	84	8		330					435
Namu[c]	1	2006-09-01	71	78	9	14	106	138	99	0.4		515
Red Bluff	1	2006-08-22	74	465	46	8	10	205		3	< 0.1	810
Tankeeah lower[ac]	1	2006-08-30	10	34	26	26	8	50	126	1	< 0.1	281
Tankeeah upper[ac]	1	2006-08-30	2	35	17	35	12	149	129	2	< 0.1	380
Whalen[c]	1	2006-07-26	62	137	57	12	15	61	1	0.1		345

Appendix 6. Late summer zooplankton densities and biomass estimated from 160 um mesh, vertical haul, Wisconsin net samples. Haul depth was 30 m, except where indicated (Continued).

Lake	stn	Date (yymmdd)	*Daphniidae*	*Bosminidae*	*Holopedium*	Other Cladocera	*Cyclopoida*	*Calanoida*	Macro inverteb.	Nauplii	Other	Total
						density (#/m^2)						
Alastair	1	2009-09-15	20,744	322,110	180	22	106,256					449,311
Batchellor	1	2006-08-22	60,094	6,626	2,343	872	4,591	31,921		7,524		113,972
Bowser	2	2009-09-04	11	11			5,544	22				5,587
Elbow	1	2007-08-29	181,117	9,007			362,997			1,547		554,668
Fred Wright[c]	1	2009-09-10	56,422	40,041	8,561	2,022	110,417	640	101	404		218,609
Keecha[c]	1	2004-08-30		31,851		398	5,101	18,759	111	1,177		57,397
Kimsquit	1	2007-08-27		37,567	49,234		95,056					181,857
Kitlope	1	2007-08-27	333	867			9,897			228		11,325
Koeye[c]	1	2006-09-01	64,988	62,366	6,899	4,415	63,746	40,980	177	2,760	11	246,341
Kooryet	1	2004-08-30		29,045		92		28,312		514		57,962
Kwinageese	1	2009-09-08	3,086	60,399	20,752		305,501	139,351				529,090
Lonesome	2	2007-08-26	115,091	7,643			79,211	11,704		1,023		214,672
Meziadin[b]		2009-09-17	83,463	8,983			125,035	8,585				226,066
Moore	1	2004-08-28	285	37,424	1,614	285	4,189	8,367		703		52,868
Morice	4	2009-09-21	2,513	19,010	512		137,920					159,955
Namu[c]	1	2006-09-01	18,624	70,170	5,109	16,182	72,603	34,950	163	1,568		219,367
Red Bluff	1	2006-08-22	14,007	214,547	12,214	4,178	5,786	53,999		15,428	321	320,481
Tankeeah lower[a,c]	1	2006-08-30	7,433	28,054	17,290	29,339	6,145	14,251	548	4,357	171	107,588
Tankeeah upper[a,c]	1	2006-08-30	751	32,949	16,193	44,649	8,794	40,316	291	5,536	211	149,689
Whalen[c]	1	2006-07-26	15,614	83,538	20,422	14,987	10,860	6,755	36	635		152,848

[a] haul depth = 20m

[b] average of stations 1 & 2

[c] Macro_Invertebtates are mostly *Chaoborus*, except in Fred Wright Lake, where they are *Chironomids*